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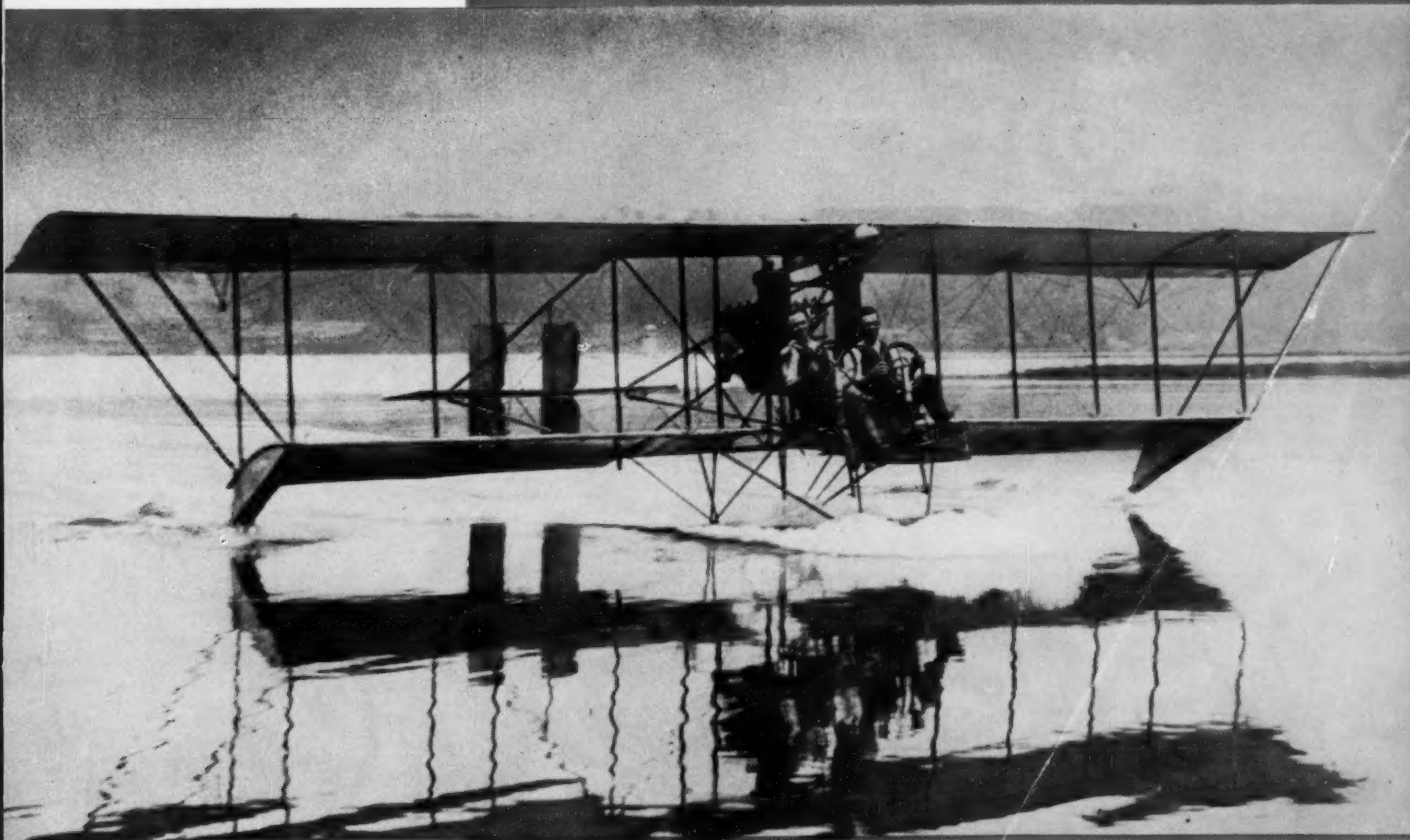

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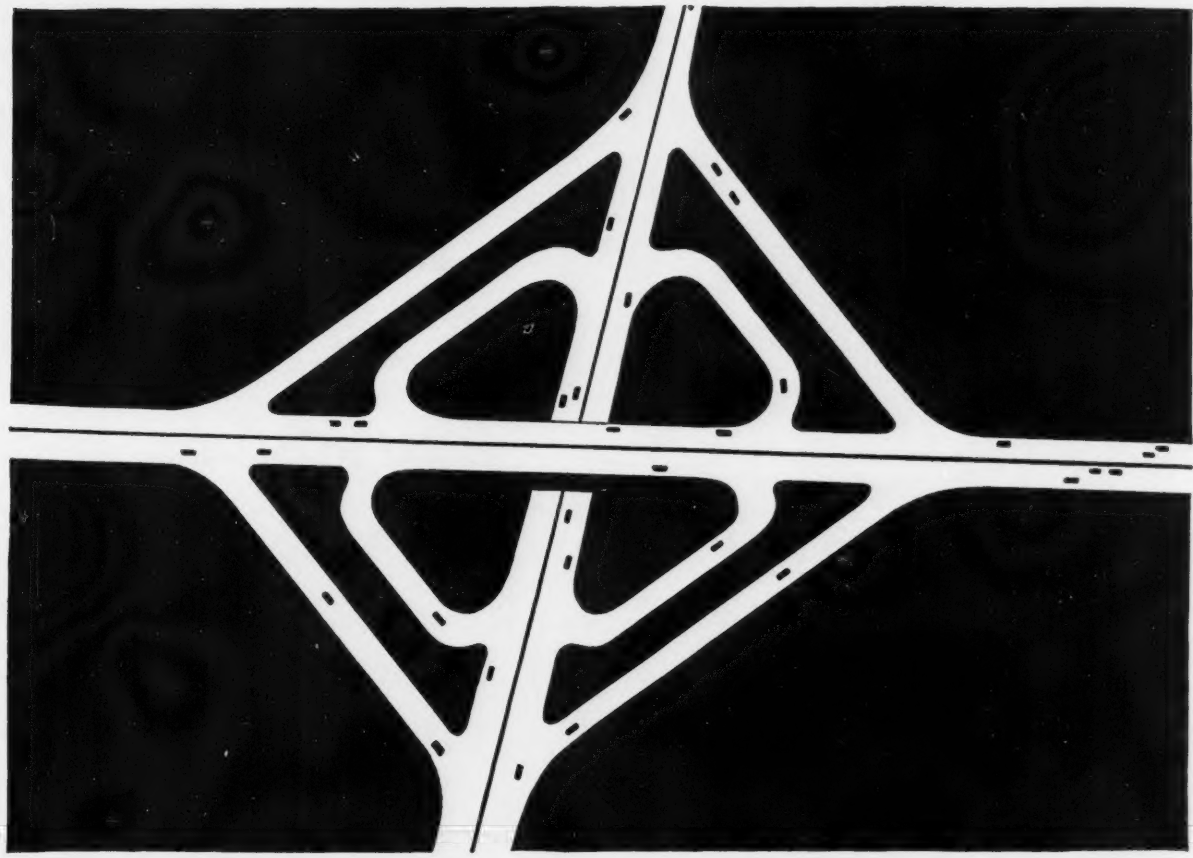


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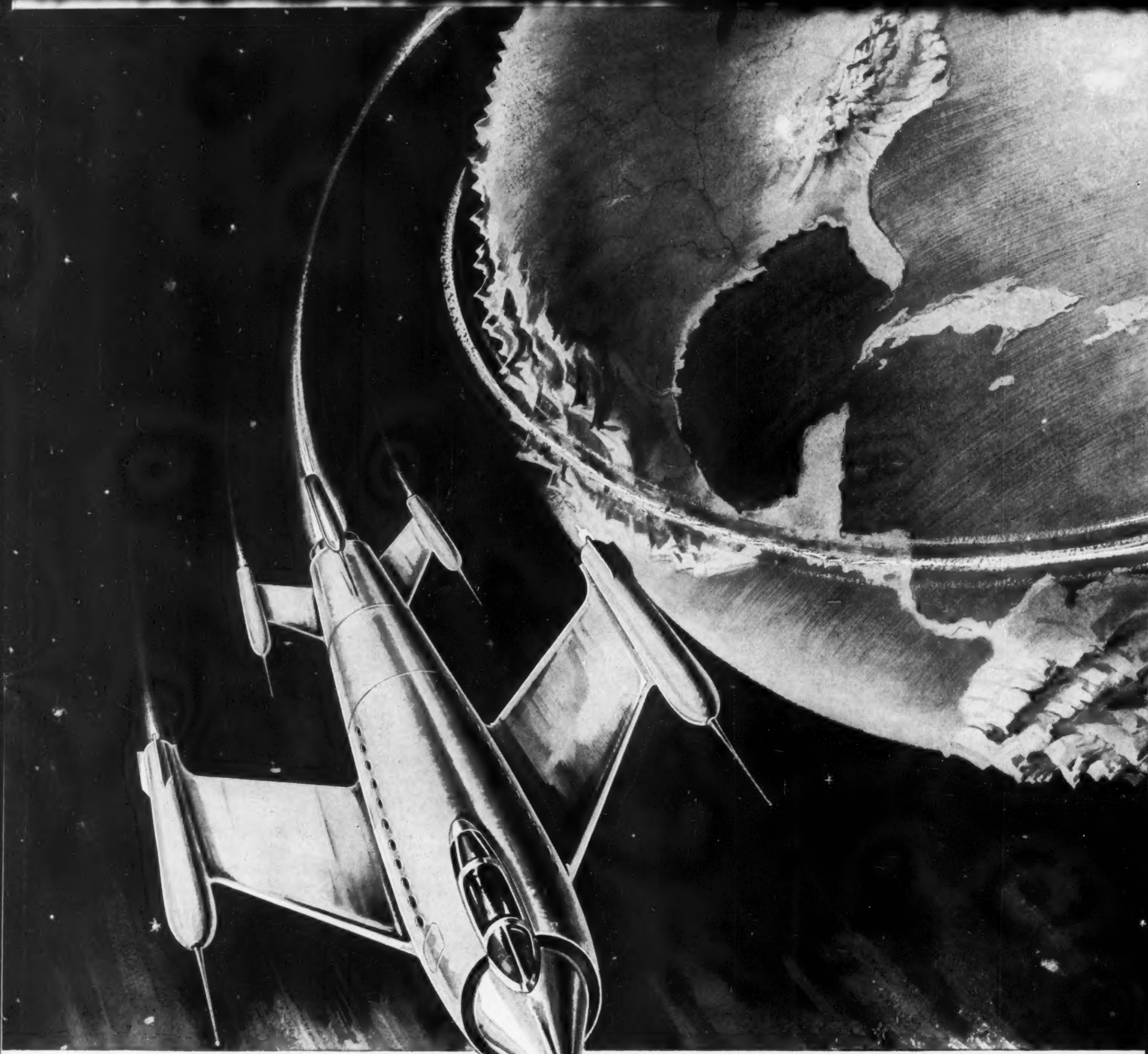

Founded 1885

THE CORNELL engineer

MARCH, 1955 VOLUME 20 NO. 6

COVER—One of the first Thomas Brothers designs, the TA airplane was built in Bath, N. Y. before the company moved to Ithaca. (See page 12.)

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Cleaner Air on Demand

by PETER CRIMI, ME '58

Illustrations courtesy of Trion, Inc.

As industries have adopted better and more complex methods of production, and as businesses have expanded, working for larger volumes of sales at smaller margins of profit, they have begun to look for cheaper and more efficient ways of keeping the air clean. Out of this demand has come the development of the electrostatic air filter. Those who use this filter, integrated with standard air conditioning systems, have found they can control the quality and uniformity of their products to a higher degree than before, and have also realized substantial cuts in maintenance cost.

An electric filter removes impurities from ventilated air by first giving the particles to be removed an electrical charge, and then collecting them on oppositely charged plates. The electrostatic filter has found many applications because of its simple design and low operating cost, together with its high efficiency as compared to ordinary mechanical filters.

The principle of electrostatic precipitation was investigated as long ago as 1824 by a German named Holfeld, who conducted a successful experiment in the filtering of gases using the electrostatic principle. In 1906, Dr. Frederick G. Cottrell of the University of California actually made a practical precipitator, which was used for the control of sulfuric acid fumes in gold and silver smelting processes. Cottrell's unit, however, was not practical for air conditioning as we know it, since it generated ozone and the noxious oxides of nitrogen. But, in 1931, Dr. Gaylord W. Penny, of the Carnegie Institute of Technology, patented the design for a precipitator which could be used to filter ventilated air, and which was, moreover, much less expensive to construct and operate. Since then, and particularly after World War II, Dr. Penney's design and ones similar to it have been used in the filtering units of thousands of air conditioning systems in all phases of industry.

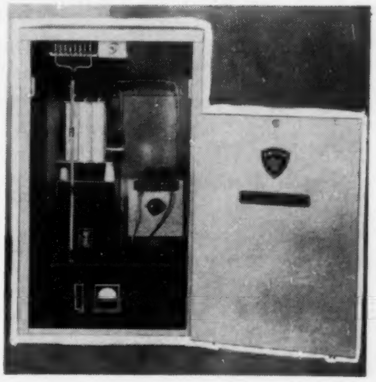
The complete assembly of an electric filter, as viewed from the air intake and access side. The vertical pipe is part of the built-in water wash system.

Electrostatic Filter Design

Electrostatic filters are made in various forms and sizes, depending on needs and operating conditions, but all have basically the same design. Air passes first through an ionizer, where the particles to be removed are given an electrical charge, then past collecting plates where the particles are deposited, and finally the air passes on out of the unit and is recirculated.

The ionizer is comprised of tubular aluminum electrodes fixed vertically along the front of the filtered unit, about 2½ inches apart. Equally spaced between the tubular electrodes, and insulated from them, are fine tungsten wires which are given a positive potential of about 12,000 volts. As the particles to be precipitated from the air pass between the wires and the tubular electrodes, they pick up positive ions which are constantly being emitted by the tungsten wires, and hence become positively charged.

Immediately behind the ionizer are aluminum collecting plates, placed vertically and spaced about ¾ inches apart. Every other plate is given a positive potential of about 6,000 volts, with the ones between grounded and insulated from those adjacent. The positively charged particles, on entering the electric field between the plates, are attracted to the grounded plates. They of course immediately lose their charge, but are bound to the plates by a water-soluble adhesive. The collecting plates are cleaned periodically by a warm water spray system within the unit, which also reapplies the adhesive. Under ordinary use, a unit only needs to be cleaned about once a month.

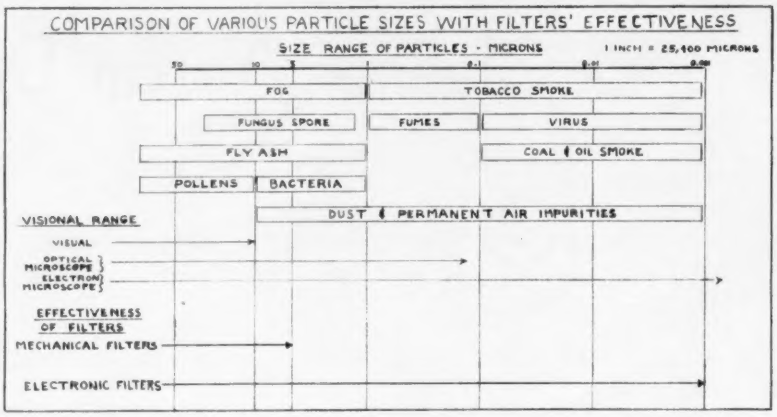


The power supply unit of an electric filter.

The power is supplied to both ionizer and collecting plates by a separate unit which draws 110 volt alternating current, rectifying and transforming it to direct current at the appropriate voltages. The power consumed only amounts to a few hundred watts, even when the filter is under heavy use.

The filters are usually housed in steel cabinets, with the ionizer-collector unit separate from the power supply unit. Smaller filters can be purchased as package units, ready to install. Larger filters, or ones having special uses, are manufactured to order, and are installed by the maker. Sizing is done by consideration of the amount of air (in cubic feet per minute) which will pass through the filter and of the efficiency desired. These factors determine the number of ionizing-collecting units needed, which in turn determine the size of the power supply unit.

The initial cost of even small units is usually too large to justify their use in homes, but one episode dramatizing the value of electronic filters involved a unit which was so used. A high school physics teacher from Donora, Pennsylvania, named P. Garrett Hayes had installed the electronic filter to alleviate an asthma condition. A deadly smog closed in on the town, killing twenty-two persons and leaving many more critically ill with asthma or lung disease. Hayes sat calmly at home, unaware of the danger around him until he heard about it on the radio. He is convinced that the electronic filter saved his life.

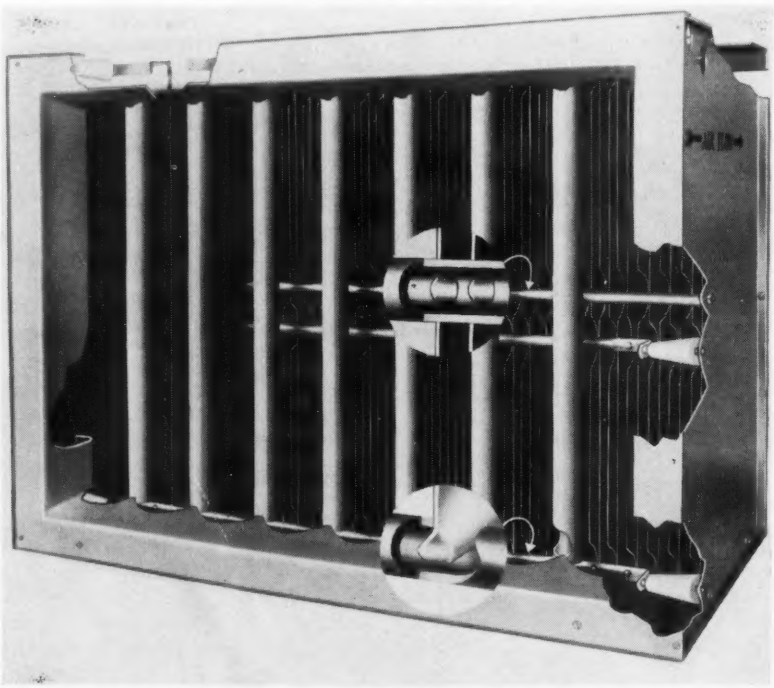


Improvements are constantly being made on the filter's basic design, both to increase its efficiency and to make it more adaptable to specific uses. An ordinary mechanical filter has been added to the clean air side of the unit, building up a slight back pressure which creates a more even flow of air out of the unit. This after-filter also prevents fouling of the general system by any large accumulations of dirt which might form and dislodge from the collecting plates if the unit is not cleaned often enough. Manufacturers have also designed a motorized plate washer and adhesive applicator which moves back and forth across the unit's face, making the cleaning operation more rapid and effective.

Filter Efficiency

The efficiency of electric filters is now known to be much greater than that of mechanical filters, but to prove this was no easy matter for the manufacturers of electrostatic filters. Before electric filters were developed, the efficiency of air filters was always determined by the manufacturers' own particular methods. Since there were almost as many methods as there were filter manufacturers, the figures on relative efficiences were deceiving, to say the least. Recently, however, the National Bureau of Standards has adopted a procedure known as the dust-spot method whereby efficiences can be accurately and impartially determined. The dust-spot method simply involves taking samples of air before and after it passes through the filter being tested, and comparing the discoloration which each sample effects on a piece of chemical filter paper. A simple way of presenting the data collected with these dust-spot tests is by comparing the size of particles which the two types of filters will effectively remove from the air.

The ionizing-collecting cell of an electric filter.



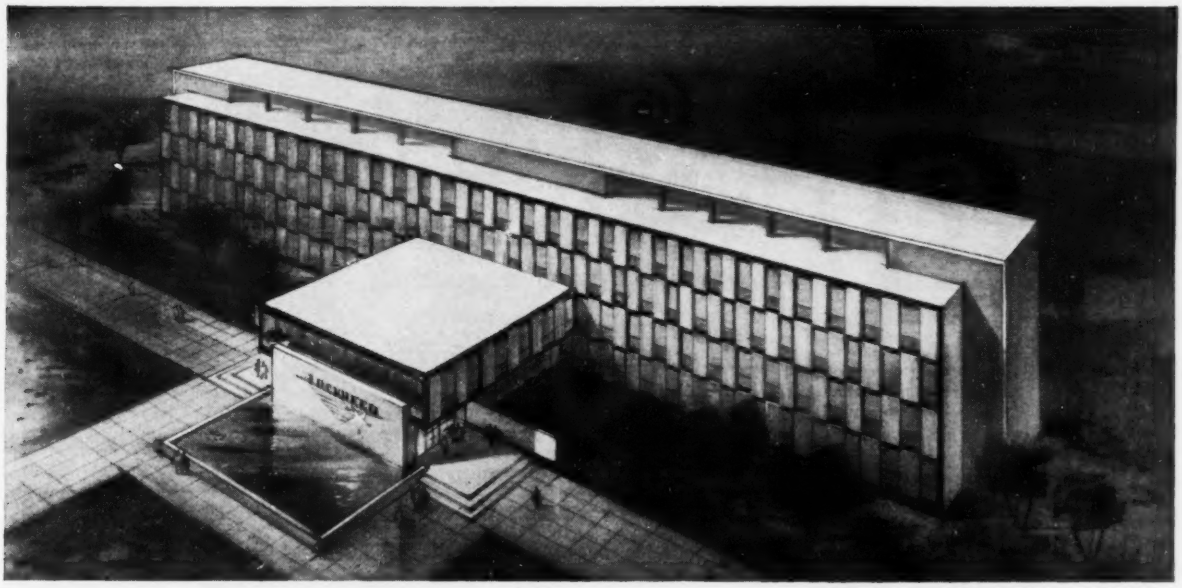
An ordinary mechanical filter, constructed of a thin pad of fibers such as spun glass, has been found capable of removing from the air particles with a diameter as small as five microns (one micron equals 1/25,400 of an inch). That would include such things as fog, flyash, pollens, and larger dust particles. However, particles having a diameter larger than five microns can not ordinarily be inhaled by humans.

Electronic filters, on the other hand, will effectively remove particles from the air which are as small as .001 microns in diameter. Impurities of this size include, as well as the ones mentioned above, tobacco smoke, fumes of all kinds, and most significantly, bacteria and virus.

Uses of Electronic Filters

Electrostatic filters have already found wide application. Hotels,

(Continued on page 66)



ITHACA, 1914

The Thomas Brothers Aeroplane Company Inlet Plant, located on Brindly Street in Ithaca.

CENTER OF EARLY AIR PROGRESS

by RICHARD BRANDENBURG, EP '58

The author is indebted to Jerome A. Fried, ME'10, and formerly general superintendent at Thomas-Morse; Paul D. Wilson, former Thomas-Morse test pilot; and Harold Andrews, Aero. E. '55, for their cooperation in sharing their factual records, personal experiences, and photos pertaining to the history of the Thomas-Morse Aircraft Division.—Photos are courtesy of U. S. Air Force and Randolph F. Hall.

Only eleven years after the Wrights successfully completed man's first powered airplane flight, Ithaca, N. Y., became the site of significant developments in the progress of aviation. Ithacans watched with cautious amazement as a series of seaplanes, racers, airplane motors, fledgling pilots, fighters, and observation craft took form, each contributing in its own right to the evolution of the modern aviation industry.

Ithaca was the birthplace of the famed "Tommy," the Thomas-Morse Scout advanced trainer of World War I. It was the home of the MB series, including the Army's first real pursuit plane and the fastest plane in the world at the end of the First World War. The first really all-metal plane was built and tested at the south end of Lake Cayuga. The design and operational perfection of the XO-6B, a two-place observation biplane of the late 20's, marked the passing of an era of winged progress for Ithaca.

There were heartaches, too. Many designs were built only once, to be test flown from the shores of Lake Cayuga, noted as inferior by daring test pilots, and then dismantled or put in storage. There were accidents, numerous close scrapes in landings and maneuvers, and power-plant difficulties. But the record of courage, adventure, trial and error advances, and concrete achievements remain. Ithaca's own Thomas Brothers Aeroplane Company, The Thomas School of Aviation, Thomas Aeromotor Company, and later the Thomas-Morse Aircraft Corporation of the Morse Chain Company, have written a vital chapter in the annals of powered flight.

Thomas Brothers Pave the Way

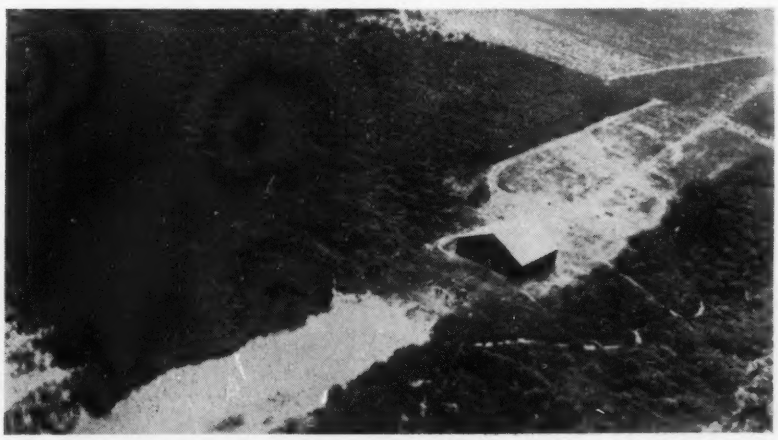
In 1914, at the invitation of the Ithaca Board of Trade, the Thomas brothers of Bath, N. Y., moved to a factory on Brindley Street, near the Lake Cayuga inlet. They brought with them a record of six years' experience experimenting with aircraft and motors, and one of the first private flying schools in the nation. A single hanger and a runway of dirt made in a lakeside peach orchard constituted the third oldest municipal airport in the country. At this field, two years after Thomas Brothers arrived in Ithaca, test pilot Frank Burnside, then holder of the American altitude record, flew an early Thomas model D-2 powered by a Thomas engine, to a world speed record of 97.4 mph.

The Thomas Brothers were successful experimenters before their arrival in Ithaca. W. T. Thomas, after his graduation in 1908 from a technical college in London, came to Hammondsport, N. Y., to work with Glenn Curtiss. W. T. Thomas joined his brother, Oliver, to found an independent company. In 1910 their first airplane was completed, a result of months of slow hand labor in a barn. The brothers then moved to Bath, where the Thomas Brothers Aeroplane Company and the Thomas School of Aviation were incorporated. The Thomas School was the first flying school chartered by the New York State Board of Regents.

Frank Burnside was a pupil of the school who later became chief company pilot. In 1913, he broke Lincoln Beachy's altitude record by flying to a height of 13,000 feet. The Thomas's 1910 plane was driven by a 22 horsepower automobile engine, and utilized a chain-driven propeller and a four wheel skid-mounted undercarriage. Flights up to twenty minutes long were successful, with one passenger aboard.

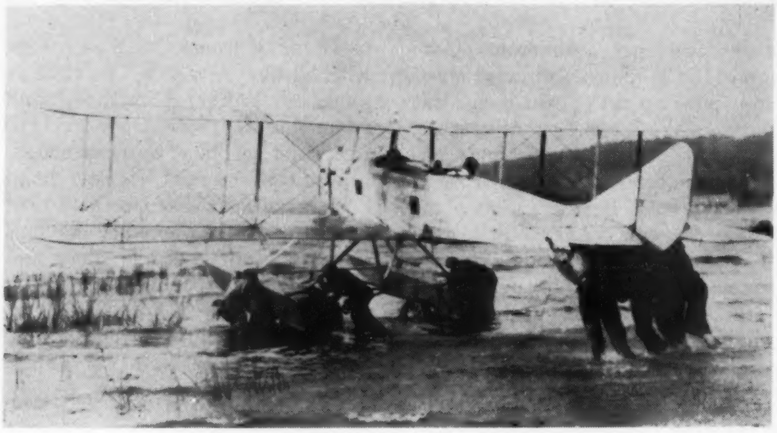
A new machine, designated the TA, was built in Bath. It was a pusher airplane, powered by a six-cylinder Kirkham motor, and capable of carrying a phenomenal three-passenger load. A pontoon version was successful in its operation as an early hydro-airplane. A slightly modified TA, with a larger powerplant, carried Walter Johnson and a passenger to an American endurance record of three hours and 51 minutes in 1912. The brothers also built a 60 horsepower monoplane and several flying boats. Two of these boats had metal hulls, consisting of 30 gauge galvanized iron covering a wooden framework.

One of the oldest municipal airports in the country, Thomas Field near Lake Cayuga consisted of one hangar and a runway in a peach orchard.



Third Thomas Sparks New Designs

B. D. Thomas, no relation to the brothers, joined the company as chief engineer and designer. He had worked in England with Vickers, Ltd., and with the Sopwith Aviation Co. Glenn Curtiss met B. D. Thomas in Paris, and asked him to come to Hammondsport, N. Y., to work with Curtiss in building a flying boat to win Rodman Wanamaker's Atlantic crossing prize. After working on flying boat designs that led to the successful World War I H series, Thomas joined the Thomas Brothers and designed the T2 tractor bi-plane. The T2 travel-



An early HS seaplane is launched in Lake Cayuga.

ed at 83 mph, climbed 3,800 feet in ten minutes with pilot, passenger, and 1,000 pound load. This impressive performance, and the fact that Thomas-Morse hired B. D. Thomas, caused the British Admiralty to order 24 of the American planes.

With this successful background, the Company and flying school found Ithaca an excellent choice for a new location. The ground at the end of Lake Cayuga was flat and easily adapted for airplane landings. The lake itself enabled experiments with flying-boats and hydro-airplanes. Even at the early date of 1914 W. T. Thomas was aware that the location was not easily accessible to the public. Cold weather made flying from the ice feasible. After the company established itself in Ithaca, its designer, B. D. Thomas, developed the D2, powered by a 135 horsepower Thomas engine. The engine was designed by George Able and Harold Bliss, who were among the founders of the Thomas Aeromotor Company. The Aeroplane Company continued to produce a steady flow of new designs, using Thomas engines. In 1915, two Navy seaplanes were built with 140 horsepower motors. These were followed by the D5, a Signal Corps craft with a 135 horsepower engine that attained speeds of 86 mph. In 1916, 15 SH-4 two-seater hydro-airplanes were delivered to the Navy. At this time, Canada sent many young men to the flying school for pilot training in preparation for Royal Flying Corps service.

Morse Buys Thomas Interests

Jerome Fried, proprietor of the Ithaca Scientific Instrument Company, who, starting in 1915, was general manager of the Thomas Aeromotor Company, states that in the later part of 1916 it became apparent that the company was "very much underfianced . . . we made efforts to do something about it, local and otherwise." Frank L. Morse of the Morse Chain Company, after conferring with directors H. H. Westinghouse, president of the airbrake company, and J. F. Miller, president of Union Switch and Signal Company, effected the formation of the Thomas-Morse Aircraft Corporation in January, 1917. The Thomas brothers' staff of about 100 personnel was to grow to 1200 as the corporation did a peak four million dollars worth of business, selling over 800 planes during World War I. The newly reorganized corporation was now ready to begin the difficult specialized process of developing a high speed fighter, first represented by the S-4, the original "Tommy" Scout.

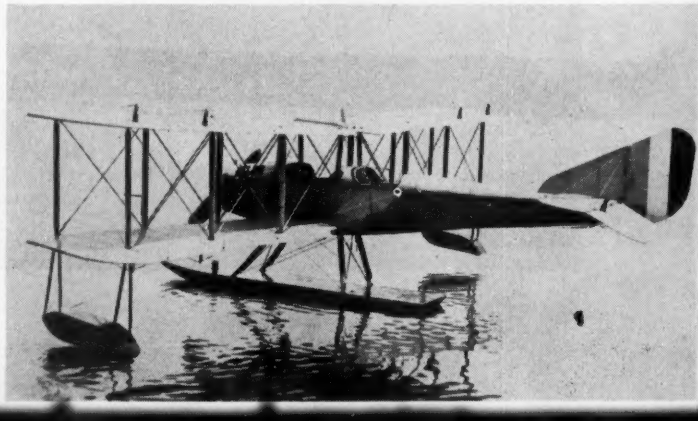
Thomas-Morse Test-Pilot Paul D. Wilson sums up the characteristics of the S-4 Scout prototype in the assertion, "It landed easily, and general flight characteristics were not bad for this period." The plane was powered by a Gnome nine-cylinder rotary engine manufactured by the General Vehicle Company, and rated at 100 horsepower. The engine could not be throttled, but RPM could be reduced by leaning the fuel mixture. Work on the S-4 was actually begun before the Thomas brothers merged with Morse. The plane was equipped with twin floats and used for both land and water operation. Its effectiveness as a demonstrator led to the placement of an order for 100 S-4's, the next in the Scout series. After this order was placed, the S-4 was used only for occasional training and exhibition flights. It had as disadvantages the fact that its Gnome engine was unsuited for cruising, and according to Wilson, a five or six pound tail heavy condition. Total flying time was less than 250 hours, consisting mainly of short flights averaging twenty minutes.

Thomas-Morse Moves to Hill Plant

With the production of the S-4B, the Thomas-Morse Corporation built its first plane at the "Hill Plant," located at the west end of the present Morse Chain plant. The original inlet plant was retained for sub-assembly manufacture. Though the first S-4 combined good handling qualities due to small size and

The British Admiralty ordered two dozen T2's, a tractor biplane designed by B. D. Thomas.

The SH-4, pictured here ready for test flight in Lake Cayuga, was ordered by the Navy in 1916.



low wing loading with stability and manueverability, the S-4B had a better rate of climb and greater top speed. Unfortunately, the Gnome engine was a problem. It was temperamental on starting, and presented a fire hazard due to its pressure-type gasoline system. The S-4B consumed over three gallons of castor oil an hour, and spewed it over the fuselage and right wing. It retained a tail-heavy condition, and would ground loop easily. In addition, control cable contraction at low temperatures made handling of the plane difficult. When the contract for the S-4B was filled, it was decided to no longer use the Gnome engine. Because over a thousand engines had been built, a great number of the powerplants were scrapped. In spite of these difficulties, the B model took off in a short distance, climbed at over 700 feet per minute, and had a ceiling of 16,000 ft.

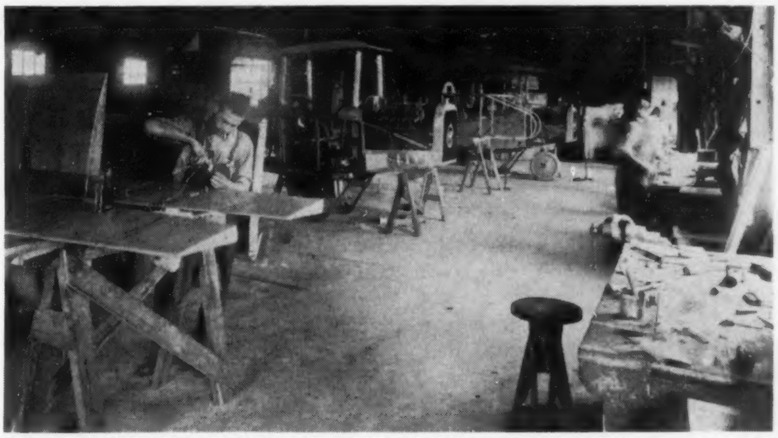
Identical in design to the S-4B was the S-5 model twin float seaplane. Six such planes were built. Test Pilot Wilson points out that the wooden floats required constant repair. Each compartment of the pontoons would require removal of water after each flight, and in service they would take on enough water to affect flight performance. However, the planes were of sufficient quality to warrant a contract for their limited production for the Navy.

Morse Produces "Tommy" Scout

An important step in bridging the gap between existing American Curtiss primary trainers and the first planes our pilots were to fly in France was the S-4C. Major design changes in the S-4C over its predecessor included revised aileron control, addition of a new powerplant (after the first fifty planes were built), reduction in size of ailerons and elevator, better control matching, and provision for armaments. The new powerplant was the LeRhone 80 horsepower rotary engine. Reduced wing loading due to the lighter-weight rotary engine provided desirable speed and climb characteristics. The weight carried per horsepower was about eight pounds, half that carried by contemporary reconnaissance types. In addition, structural weight was reduced, and short spans, small wing areas, and large control surfaces enhanced manueverability. The Scout turned sharply due to the gyroscopic effect of the rotary engine. The revolving engine would exert a turning effect that would enable fast right turns to be made. The S-4C was a low-aspect ratio biplane, the wings being constructed of spruce spars. The fuselage consisted of wire trusses with spruce and ash members and longerons. The upper deck of of the fuselage was covered with aluminum forward of the cockpit. The landing gear was a V-type structure of steel tubing and spruce fairings.

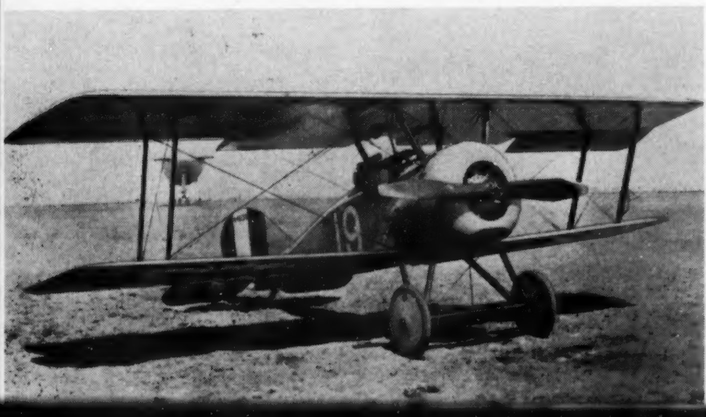
The engine itself was mounted on an X-type frame, with oil and fuel tanks directly aft of the firewall. The firewall itself, along with the engines cowling, was of aluminum, the latter being secured by automotive-type trunk fasteners. Other equipment included a single thirty-caliber machine gun on the right side of the fuselage cowling, synchronized to fire through the propeller arc by means of a hydraulic device fitted to the engine. For training purposes, cameras could be substituted for the gun.

Paul Wilson's analysis of the "Tommy" S-4C indicates that no major structural failures occured, and that in spite of the gyroscopic effect that made looping difficult, the planes were well suited for acrobatic training. He states that the first order for 400 S-4Cs was issued in January, 1918, and was followed by a request for an additional 150 in August. An order for another 500 was cancelled near the end of 1918 after nearly half of the needed parts were made. It was estimated that a total of 640 S-4Bs and Cs were delivered along with spares amounting to 232 additional aircraft. Almost all parts for the planes were made at the inlet plant, and assembly completed at the factory on the Hill. Every tenth plane



Factory construction of SH-4 two-seater hydro-airplanes was carried on at the Inlet Plant.

The S-4-C famed "Tommy" Scout advanced trainer, prepared pilots for handling hotter pursuit ships.

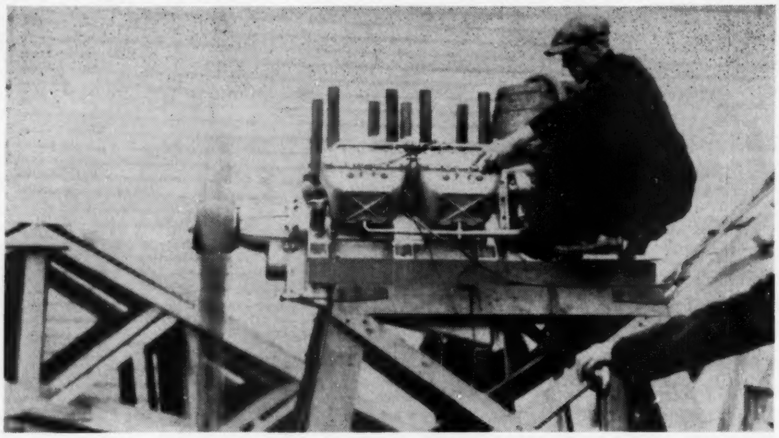


One of the first Thomas Morse Pursuit designs, the MB-1 proved a failure due to over-emphasis on weight reduction.

made was carted by truck to the field for rigging tests and performance check. The planes were then crated for shipment at the Hill Plant. Flying activities reached a peak during World War I, with a total of three pilots working for Thomas Morse, and requiring that castor oil-lubricant for the rotary engines be purchased in fifty-drum quantities.

After the major cancellation of the S-4C order at the end of 1918, a single additional plane of this type was built with special covering and a number of plated metal parts. The plane was a showpiece, placed on display at several airplane shows, and later fitted with a more powerful motor-propeller combination and an additional seat-belt for stunting. Several experimental wing types were tested with this last S-4C Scout before it was retired. The "Tommy" has been called the AT-6 of World War I. After the war, when many of the craft were sold as surplus to sportsmen, ex-army flyers, and flying schools, the Scouts continued to build their reputation as the best advanced trainer of their day.

Completing the colorful line of the Scout trainers was the Thomas Morse S-4E, a fast, highly manueverable advanced acrobatic trainer. The distinctive lines of this little plane featured sharply tapered wings, the top surface having a span of about 22 feet, and each lower wing being seven feet long. The single S-4E that was built utilized a 110 horsepower LeRhone rotary, a factor contributing to its failure to be accepted, since the rotary-type powerplant was obsolete. Though the fuselage was similar to the S-4C, the plane had completely re-designed tail surfaces and modified landing gear .Its unfavorable characteristics included marked tail-heaviness and inadequate propeller ground-clearance.



Engine tests were conducted in Ithaca on products of the Thomas Aeromotor Company like this D-8 power plant.

The S-4E was flown only in Ithaca until it was sold and refitted with a Aeromarine 737 cubic inch engine for racing. The ship was entered in several events in National Air Races and won one, with an estimated top speed of about 145 mph. The soundness of its design is reflected in its effective performance with increased horsepower.

Rotary-Powered Craft Perfected

Called the best plane ever built around a rotary engine by Thomas-Morse, the handling characteristics and performance of the S-6 brought a multitude of favorable comments from test pilots. However, the company's hopes for a production order were in vain. The rotary engine proved unacceptable. The plane had a 29-foot span, a top speed of 105 mph, a landing speed of 35 mph, and a ceiling of almost 20,000 feet. The ship was flown cross country to Washington and Dayton in the first T-M flights of any length made up to the time of its construction in 1919. Placing second in the National Air Races in Kansas City, the S-6 finished the hundred mile event with a speed only one mph less than the winning Curtiss racer with twice as much horsepower. It was used for many acrobatic shows throughout New York state.

The ability of the S-6 to maintain level flight at low RPM, combined with its light controls and good landing and taxiing qualities, made the plane a pleasure to fly, according to test pilot Wilson. He points out, however, that the plane was slightly tail-heavy, cockpit was cramped, and castor oil sprayed into the cockpit and onto flying suits from the engine. In spite of these defects, Wilson's admiration for the S-6 is summed up in his exclamation, "It was a honey!"

Side-By-Side Seating Attempted

First in a series of two airplanes incorporating a distinctive side-by-side seating arrangement was the S-7. The S-7 was also the only ship not designed by B. D. Thomas. Its engineering group included W. T. Thomas, one of the founding brothers. The S-7 was designed, built, and flown within a twenty-nine day period, and made a non-stop trip from New York to Ithaca after its exhibition at an air show. The plane was sold along with the S-4E, to a pilot associated with Clarence Chamberlain. Reports indicate it

The successful MB-3 was ordered in large quantities by the Air Service.

The radical "post-office plane," the MB-4, featured twin fuselages and two Hispano engines mounted in a central nacelle.

was used for mapping, and finally crashed in New Jersey. Again, selection of powerplant restricted the demand for this Thomas-Morse plane. It is probable that had another engine been used, the plane would have been built in limited numbers.

The second side-by-side trainer was the S-9, built for a trainer to avoid continued accidents resulting from pilot failure to "look both ways." However, only one model was built because the government's plans did not materialize. The S-9 was a widened S-6 with an all-metal fuselage and Wright radial engine. It had a short take-off run, high rate of climb, top speed of 140 mph, and landing speed of 40 mph. The plane's cockpit was too narrow, and the pilot's position too high when he wore a parachute. During its test flights, the S-9 had several close scrapes. While the craft was still in Ithaca a delicate landing was made in fear that a failed wing-fitting strut would fall into the propeller path. Landing was safely made, however, and the plane built up substantial flight time in Dayton and at Kelly Field. At Kelly, a fuel line failure caused a forced landing. Several months later, structural difficulties caused the pilot to parachute to safety as the S-9 crashed. The plane's performance, well above average for ships of its type, marked the S-9 as "one of the better planes built by Thomas- Morse Company," according to Paul Wilson.

Thomas-Morse Enters Pursuit Field

A radical new design trend influenced the next chapter in the aviation history of the Thomas-Morse Company. Shifting from scout and trainer planes to the tricky development of fast pursuit fighters, the company's MB-1 was a disappointing forerunner of the best pursuit ships of the twenties. The MB-1 was built in the experimental plant located on Center Street. Reduced weight keynoted the design philosophy, to the extent the almost all metal parts were drilled with lightening holes, mahogony plywood bulkheads were cut away where possible, and even the control stick was perforated. Arriving in a guarded car, one of the first Liberty 12 engines released was fitted to the MB-1. An atmosphere of secrecy surrounded the entire construction of the plane.

But the MB-1 was doomed to failure. By the time it reached the airfield after being towed by a small truck, the undercarriage had already been weakened to the extent that modification was necessary. As the plane sat in the hanger, the tail-skid fittings failed and the skid broke through the vertical fin. Initial taxi and flight tests were cautiously begun on the ice of Lake Cayuga, frozen nearly its entire length during that winter. The landing gear collapsed as the tail was gingerly brought up to flying position. After this failure, the plane made one more short flight before it was abandoned. The disappointing behavior of the MB-1 did not stop continued attempts to master the intricacies of fighter plane design. In looking back on the tedious struggle for a successful model, Paul Wilson pinpoints the spirit of determination that characterized Thomas-Morse workers: "The pioneer has a rough road to travel."

A second failure was to pass from the drawing board to prototype construction before Thomas-Morse "clicked" with a workable pursuit ship. The MB-2 was built around a Liberty 12-C engine utilizing spur-gear reduction. This biplane design had a 32 foot span, the top wing having front and rear spars, and the lower wing having an additional center spar as well. Twin radiators located in the lower wing stubs were to provide cooling for the radical design. Many untried ideas utilized in its design made it doubtful that the MB-2 could have been brought to successful development even if an acceptable powerplant were available. The second fuselage of this two-place fighter was about half completed when the project was discontinued. At this time the factory converted about 75 DH-4s to improved DH-4B aircraft for the government.

MB-3 Is Outstanding U. S. Pursuit

The Thomas-Morse MB-3, first flown in February, 1919, became the first post World War I fighter ordered in quantity by the Army, and the nation's standard pursuit during the twenties. In an attempt to build a plane to outperform all existing designs, the designers of the MB-3 drew upon European and American design influences, uniting in a single plane the best characteristics available in existing craft. The first of the original four MB-3s built at the Hill Plant was shipped to McCook Field, near the present Wright-Patterson Field, in Dayton. There the plane underwent static-testing, sandloading indicating a wing-structure safety factor of ten, individual-spar safety factor nearly twice that required, and allowable-control-surface loads to be half again those required in the contract.

Actual flight tests revealed the plane's amazing performance. The MB-3 climbed to ten thousand feet in four minutes and 52 seconds. Starting from level flight, the plane would climb nearly 2000 feet in a nearly vertical attitude. A Model H Hispano powerplant developed an actual 355 horsepower, propelling the plane at a record breaking rate of 163.68 mph. That the MB-3 was a tough little ship was proven

The MB-9, pioneering all-metal plane, was converted from an MB-10 trainer to pursuit ship by attaching a single cockpit forward section and more powerful motor.

Probably the smallest plane for its time using a power plant as large as the Curtiss D-12 engine, the nose-heavy TM-23 rolled over on its back during a landing accident.

when leading edge failure of the top wing occurred during a test dive. The pilot was able to land safely, even through the top fabric was shredded and even knotted in places. As a result of this incident, the plane was returned to Ithaca, where leading edge changes were made, and a comprehensive wing pressure study made to improve future designs.

The MB-3 had several weaknesses in spite of its outstanding performance. Typical of other Thomas-Morse designs, the plane had inadequate cockpit room. Cooling of the powerplant was also ineffective. Maintenance was tedious, and many hose connections were difficult to replace. A pilot's flight test report notes the ineffectiveness of the fuel system, including main tank leakage and rotting of structure due to trapped oil overflow. The plywood motor mount was attached to bulkheads by aluminum rivets that would shake loose in a short time due to extreme engine vibration. Another irritation was the plane's difference in balance when the radiator shutters were opened or closed. However, the MB-3 so outclassed its competitors that the Air Service ordered 50 planes with an unofficial acknowledgment that a bigger contract would follow for 200 more. The company prepared for this larger order with large expenditures for jigs and dies. Though six additional MB-3s were built for the Navy, the larger contract was to go to a young west coast concern destined to become an aircraft industry leader.

Boeing Gets Production Contract

In an attempt to rejuvenate and sustain the nation's struggling aircraft industry, the government revised its purchasing policy to allow open bidding on contracts for building existing planes in large quantities. The young Boeing Company of Seattle, Washington put in its bid for 200 Thomas-Morse MB-3As, a modified version of the MB-3. The newer version eliminated the objectionable radiator shutter balance change by utilizing two side-radiators. Other changes included improved aileron control through modification of control surface size, and an overall heavier construction that reduced some of the "hot" performance qualities of the original design. The MB-3A had a top speed of about 140 mph, cruised at 125 mph, and landed at 55 mph. It had a service ceiling of 19,500 feet. Boeing's reputation of reliable workmanship, and its attractive low bid gave it the contract for the 200 MB-3s.

The reaction to the contract loss at Thomas-Morse was a considerable jolt to the Ithaca Company. Though it was a blow to the original designers and builders, the MB-3 contract established Boeing as a prominent aircraft manufacturer. It was a turning point in the history of a company that was to later produce the Flying Fortress, the B-29, the Stratocruiser, and America's first jet airliner.

Boeing filled its contract by late December in 1922. During the following years, the MB-3As were the mainstay of America's fighter squadrons. The plans saw service all over the country until the introduction of the faster Curtiss P-1. Then, the MB-3As were used as trainers until they were removed from service in 1929. The MB series originating in Ithaca earned a respected page in the history of military aviation progress by establishing the prominence of Boeing, and by serving as the first quantity-built American pursuit ship.

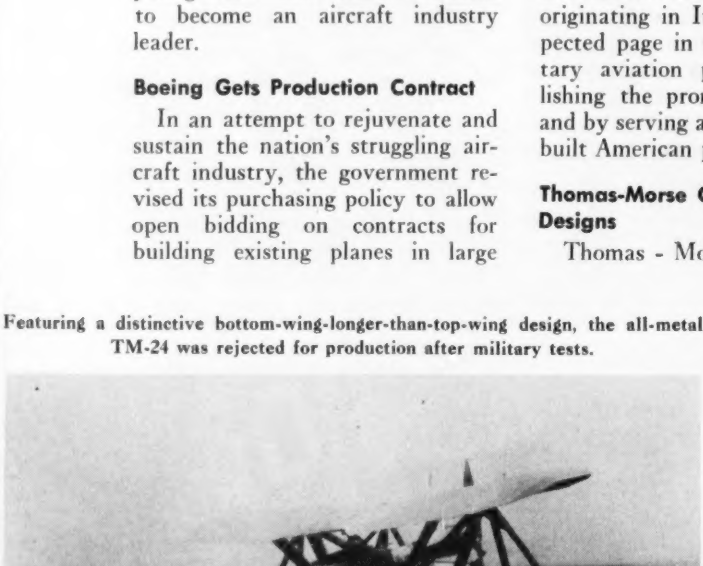
Thomas-Morse Continues New Designs

Thomas - Morse continued its search for new saleable airplanes with the development of the distinctive MB-4 mail plane. The MB-4, however, never left the experimental stage. Its power was provided by two 300 horsepower Hispano engines, one operated as a pusher and the other as a tractor mounted on a central nacelle. Two fuselages, with individual tail surfaces was incorporated in the odd configuration. Mail compartments were located between the two engines and in back of the pilots' seats. The need for separate controls in the two fuselages involved difficult and lengthy assembly problems. There was no means of communication between the two cockpits. The plane's test flights revealed that the fuel system was unsatisfactory, since the fuel supply depended on a wind-driven pump.

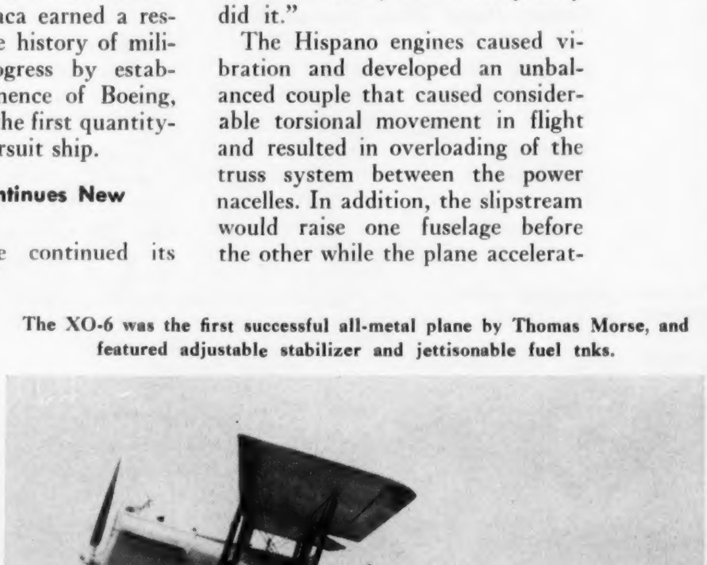
Paul Wilson, who aided in designing and test flying the MB-4, relates the dangerous procedure that was often followed to reduce the time and difficulties involved in getting both pusher and tractor motors started. Wilson explains, "We finally used a foolhardy method that worked, but caused me to question my mental level. An assistant would grasp my belt in the rear. After calling for 'switch off', these engines could be rocked against compression several times and then spun by using both hands. After getting it up to a fair speed the 'switch on' signal was given and the engine took off right in your face. The slightest slip would have been fatal, but we frequently did it."

The Hispano engines caused vibration and developed an unbalanced couple that caused considerable torsional movement in flight and resulted in overloading of the truss system between the power nacelles. In addition, the slipstream would raise one fuselage before the other while the plane accelerat-

Featuring a distinctive bottom-wing-longer-than-top-wing design, the all-metal TM-24 was rejected for production after military tests.



The XO-6 was the first successful all-metal plane by Thomas Morse, and featured adjustable stabilizer and jettisonable fuel tnks.



The MB-10 all-metal design and test pilot Paul D. Wilson.

ed for takeoff, making takeoffs impossible. The test pilots refused to fly the ship unless parachutes were provided. Two chutes, costing $1,100, were purchased in Chicago, and were the third and fourth parachutes ever sold. The radical MB-4, classed by Jerome Fried, by now general plant superintendent as "the worst thing on wings," was finally dismantled after it was found useless by the Air Corps.

Racers Next In Thomas-Morse Line

Two racing planes followed the Thomas-Morse failure in the mailplane field. The MB-6 was an MB-3 with shorter wings and fuselage. Its top speed was probably over 180 mph. The MB-7 was flown several times in Ithaca, and later was entered in the 1921 National Air Race in Omaha. During a trial flight a temporary repair on a fuel pump failed, and a forced landing on rough terrain resulted in almost complete destruction of the aircraft. The pilot escaped with a broken hip. Several minutes after the crash, a bystander dropped a match and the remains were completely burned. A second MB-7 was flown though not successfully, in the 1922 Pulitzer Race in Detroit. The planes were the only monoplanes bulit by Thomas-Morse prior to their transition to all metal construction.

Thomas-Morse Pioneers Metal Aircraft

Thomas-Morse again pioneered in another phase of aviation development when it entered the problem packed realm of all-metal aircraft design. The MB-9 and MB-10 were the first such planes. The MB-10 was a two place trainer. By removing the front cockpit and forward section of the ship, and attaching a mount for a more powerful motor, the trainer version became the MB-9 pursuit ship. Though the trainer had terrible handling characteristics, the pursuit was a little better. Cramped cockpit size, weak undercarriage, and ineffective radiators plagued the MB-9-10 series. However, practical experience was gained in all-metal construction. The U. S. Aluminum Company produced the first extruded dural wing beams used in the Thomas-Morse planes. Limited size of stock required the purchase of many parts from Vickers in England. The unconventional construction method met with criticism from all sides, and resulted in the planes being nicknamed "flying washboards."

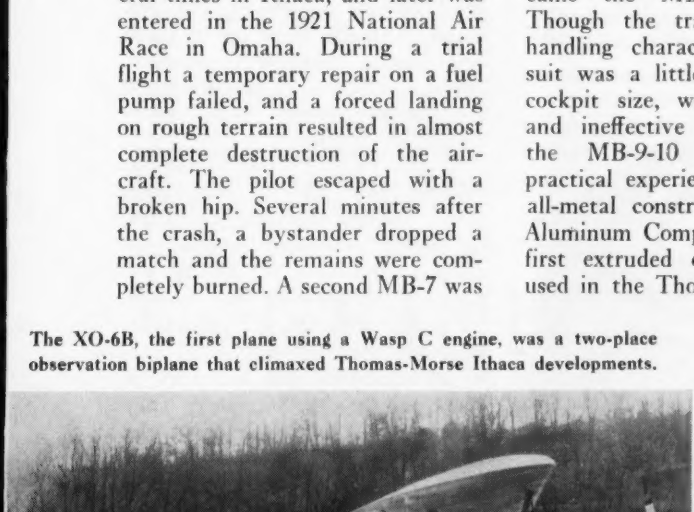
The next all metal plane was the TM-22 powered by a "600" Packard engine. The fuselage was constructed of corrugated dural riveted to shaped rings that were opened up or drilled to permit riveting. The radiator, located under the fuselage and housing oil tank and cooler, was made of extruded copper tubes that were nested in a form and then dipped in solder. The plane was flown in the National Air Races in 1922 at Selfridge Field in Mount Clemens, Michigan.

TM-23 is Next Metal Venture

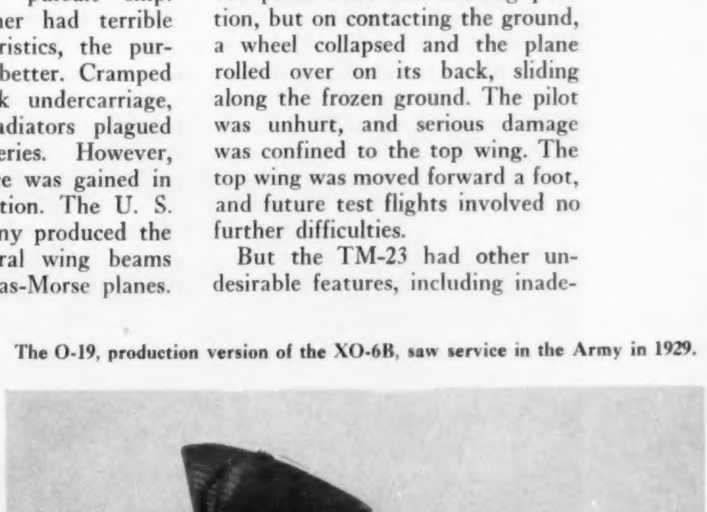
Designed as an "alert pursuit" plane, Thomas-Morse sunk a substantial amount of money and time into the development of the TM-23. The first design had twenty-foot span wings and a fuselage length of 16 feet. Fitted with 425 horsepower Curtiss D-12 engine, it was probably the smallest plane to date using such a large powerplant. A narrow fuselage made the use of a seat-pack parachute very difficult, and emergency escape doubtful. During taxi tests, the TM-23 hit a frozen ridge, making a sudden climb necessary to prevent damage. The airborne ship was found to be noseheavy, and a crash seemed emminent. Skillful piloting brought the plane back into landing position, but on contacting the ground, a wheel collapsed and the plane rolled over on its back, sliding along the frozen ground. The pilot was unhurt, and serious damage was confined to the top wing. The top wing was moved forward a foot, and future test flights involved no further difficulties.

But the TM-23 had other undesirable features, including inade-

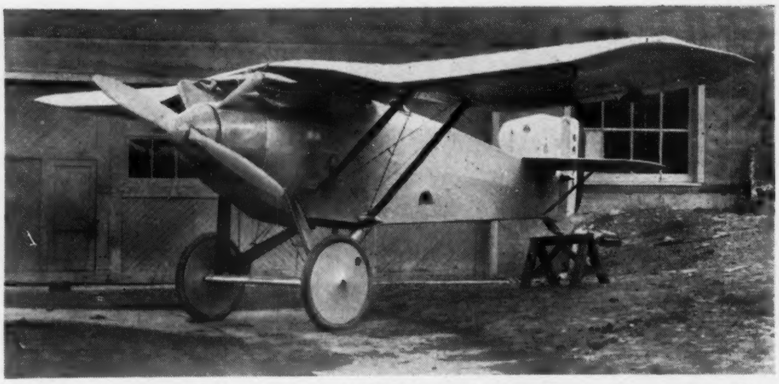
The XO-6B, the first plane using a Wasp C engine, was a two-place observation biplane that climaxed Thomas-Morse Ithaca developments.



The O-19, production version of the XO-6B, saw service in the Army in 1929.



quate cooking, abnormal stick forces, and poor control characteristics. The plane was again returned to the factory. This time the fuselage was lengthened about twenty inches ahead of the pilot's cockpit. Braced wings, with five feet greater span were added. Top speed improved, reaching about 19 quested to fly the TM-23 to Dayton, he felt that its performance made such a trip inadvisable. The ship was then sent to McCook field, and test flown. Its oil radiator failed on the first flight, and subsequent trials resulted in considerable unfavorable comment on the Thomas-Morse design.



An entry in the 1921 National Races, the MB-7 was the first Thomas Morse monoplane.

Radical Plane Disappoints Builders

A two place fighter or observation biplane was a near success. The craft, designated the TM-24, had the unusual feature of a longer bottom wing than top wing. The short fuselage was of corrugated dural resembling previous metal models. It was the first metal plane to exhibit normal flight characteristics among the T-M products. Considerable test flights were made in Ithaca before the plane was flown to McCook Field for government tests. The flight west was finally made in bad weather, the trip west of Cleveland being made at a temperature of twenty-below. The TM-24 was favorably received by the McCook test pilots. The company was certain that an order for a small quantity would be forthcoming. However, one of the final tests showed that the rudder was almost completely blanketed when the gunner stood up in his rear cockpit. Since lengthening the fuselage to alleviate the condition introduced a number of other problems, the project was dropped.

XO-6 is Successful Metal Craft

Thomas-Morse's struggle for a workable all-metal design was rewarded in the development of one of the last planes manufactured on South Hill in Ithaca. The XO-6 utilized the largest dural extruded spars made up to the mid-twenties. The XO-6 was an adaptation of the Douglas 0-2 all-metal design to use up a large number of surplus Liberty 12 engines. The plane was the first TM design with an adjustable stabilizer. Jettisonable sixty-gallon gas tanks were located in the lower wing stubs. The second production model of the XO-6 was flown to Galveston, Texas, and left in an open hanger to test salt-air effects on its dural skin. The government purchased six planes of this type, which were favorably received by pilots who built up a large amount of cross-country flying time in them.

The first in the line of Thomas Morse Scouts, this S-4 was powered by a 100-horsepower rotary engine.

Last Observation Plane Ends TM Activities

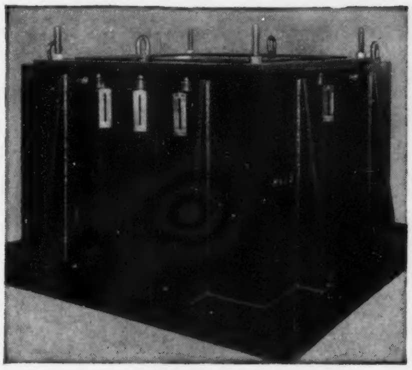
Climaxing a long, colorful record, the Thomas-Morse Aircraft Corporation of the Morse Chain Company developed the XO-6B. The plane was the first machine using a Wasp C engine, rated at 425 horsepower. The plane cruised at 125 mph, and passed flight testing in Ithaca with flying colors. The plane, designed as a two place observation biplane, was the first TM ship to be received with real enthusiasm since the MB-3. It was the first Thomas-Morse plane to use brakes. The XO-6B had excellent stall characteristics, and ample control response even at high angles of attack. It landed on small fields, could take off in a short distance, and had a rate of climb considerably faster than other designs in its class.

At this time, Thomas-Morse developed the XP-13 observation plane. Shortly thereafter, in 1929, the Army purchased several production versions of the XO-6B, designated O-19s. Other models, designated the 0-20, 0-21, and 0-23, were modified for service as personal planes for the Secretary of War and the Air Secretary. They were the last planes built at the Hill Plant.

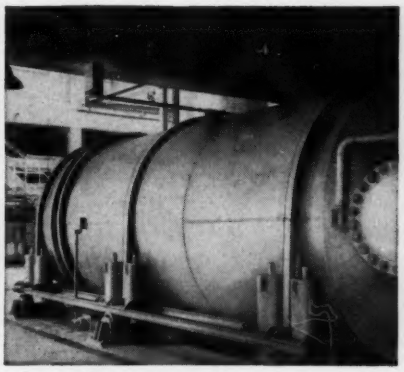
TM is Part of Growing Tradition

Ithaca's history as a center of manufacturing and flight testing had come to a close. On August 9,

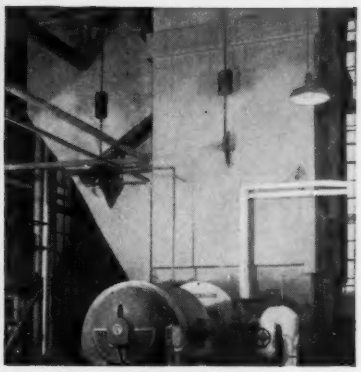
(Continued on page 66)



Base for supporting refinery tower, provided with Grinnell Spring Hangers for flexible support.



Grinnell Spring Hangers on large vessel of catalytic cracking unit in oil refinery.



Induced draft duct and blower in power station. Operates at about 500°F. Supported by Grinnell Spring Hangers.

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There are many industrial installations where heavy loads must be firmly, but flexibly, supported to keep them under control. Thermal expansion and contraction, of course, can move ponderous objects many inches. Shock and vibration, too, can make rigid support of heavy loads hazardous, due to possible serious trouble at terminals.

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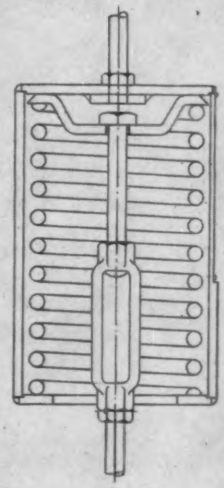
- Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- Solid steel casing protects spring from damage and weather. Guides assure continuous alignment and concentric loading of spring.
- 18 sizes available from stock — load ranges from 53 lbs. to 12,000 lbs.
- Easy selection of proper sizes from simple capacity table.
- Installation is simplified by integral load scale and travel indicators.

**Precompression is a patented feature.*



VARIABLE SPRING HANGER FIG. B-268

Fig. B-268, Type A, is designed for attachment to its supporting member by screwing a rod into a bushing in the top cap of the hanger. Adjustment of the hanger load is accomplished by turning the turnbuckle on the lower hanger rod until the hanger picks up the load and the load indicator points to the desired position. Six other types of attachment are available.

Grinnell Variable Spring Hangers are also available in half sizes (Fig. B-82); and in double spring sizes (Fig. B-98).

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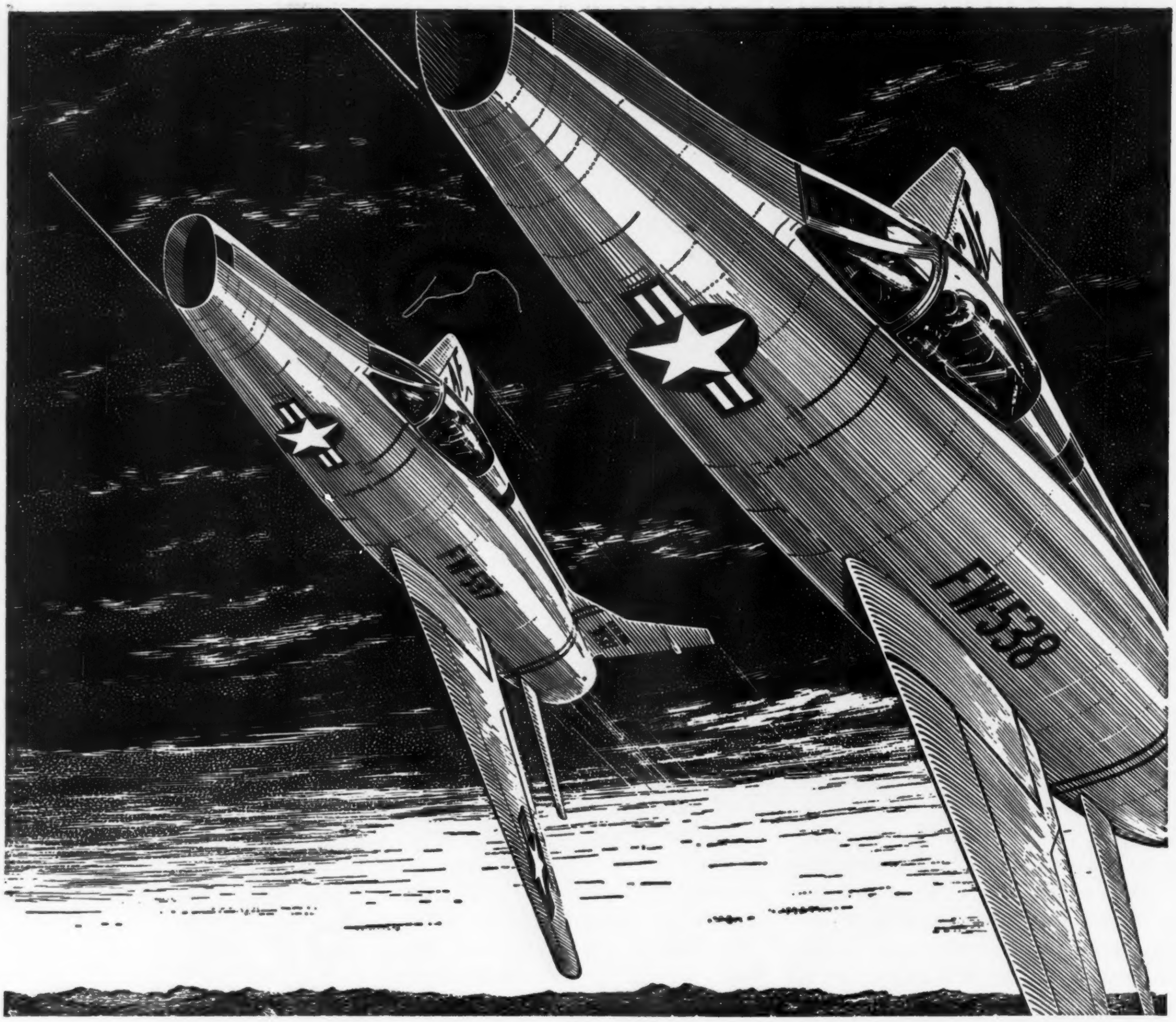
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**A MESSAGE TO
COLLEGE ENGINEERING
STUDENTS**

from Donald C. Burnham, Vice-President
Manufacturing,
Westinghouse Electric Corporation
Purdue University, 1936

To the young engineer with a creative mind

America is on the threshold of the *automation era.*

New automatic machines with their electronic brains are opening the way to a tremendous industrial development in which machines will largely replace man's routine brainwork and handwork.

Westinghouse is taking a leading part in developing equipment for the automatic factory. At our new Columbus, Ohio plant, refrigerators move along *27 miles* of automatic conveyors, with many parts being installed by automatic assembling machines...refrigerator controls are automatically calibrated... automatic testing devices maintain quality control...and the crated refrigerator is automatically conveyed to warehouse storage.

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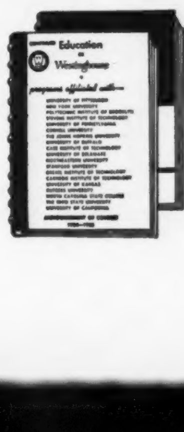

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Keeping Up To Date On
ATOMIC ENERGY - III

by STUART BRAUN, ME '57

Illustrations courtesy of Scientific American

During the nine-and-a-half years since the end of World War II, the public's, and also the government's, attention as regards atomic energy development, has been focused upon the perfection of nuclear weapons designed to insure our military security; but within the past few months, much resources and effort have been placed upon the initiation of experimentation in the nuclear power field. Prodded not only by the necessity to keep astride of Russia's nuclear power development, but also spurred on by the fact that economically practical power for peacetime uses from nuclear fuels is not as far away as was commonly believed, the AEC has formulated an atomic power plant program. Last spring over $200,000,000 was appropriated to carry through experimentation in five reactor designs which the Commission believes show the greatest promise in delivering economically recoverable electric power; private industry is to work with the AEC to make these five reactor designs reality.

A reactor is no more than a controlled A-bomb; the fission of atomic nuclei is subjected to regulation through various types of controlling media so that runaway atomic explosions will not occur. All reactors produce tremendous amounts of heat, and it is this heat which will be employed in power plants to generate steam which will in turn operate turbines, the process culminating as current travels through the power lines from the generators. But during the last war, reactors were needed soley to manufacture fissionable material, plutonium-239, through the transmutation of U-238. So much heat was produced by the Hanford reactors that a large portion of the Columbia River had to be pumped through them to carry it away. At that time, little thought was given to utilization of this heat, but today we are greatly interested in just that.

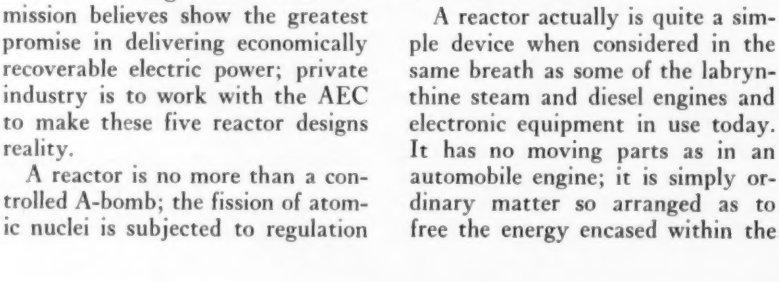
Reactor Elements

A reactor actually is quite a simple device when considered in the same breath as some of the labrynthine steam and diesel engines and electronic equipment in use today. It has no moving parts as in an automobile engine; it is simply ordinary matter so arranged as to free the energy encased within the atom for man's use. Reactor elements include: (1) nuclear fuel, either pure fissionable material or non-fissionable material enriched in fissionabales, such as natural U-238 with 15% U-235, (2) a shield to prevent tissue-destroying radiations from escaping to the outside, usually concrete, (3) a medium designed to control, to initiate and terminate, the fission reactions; that is, some neutron-absorbing material such as the cadmium rods used in the Hanford piles, (4) a coolant to conduct away the heat generated by fissioning atoms to the boilers, such as water, air, or liquid metal, (5) a moderator, a device whereby the neutrons, leaving split atoms at thousands of miles per second, are slowed down to so-called "thermal" speeds. Pure fissionable material, such as U-235, absorbs slow neutrons at a greater rate than does non-fissionable material; however, fast neutrons are absorbed by both at nearly the same rate. Thus, moderators are not needed where pure fissionables are used; but when non-fissionable fuel, say U-238, enriched in fissionable U-235 is used, moderators must slow down the fast neutrons for too many will otherwise be absorbed in the non-fissionable component, thus quenching the chain reaction. Any of the five reactor elements may be varied as to composition, weight, etc. Consequently, many reactor designs have been proposed by nuclear scientists and engineers, as radically different as night and day. No one will know which is the most economically efficient until experimentation with the different types has determined their relative merits.

Reactor History

There follows a brief summary of the design and functions of the

Fig. 1. Pressurized water reactor will have four loops to conduct coolant from the reactor core. One loop will serve as a spare (only two loops are shown here.) The fuel elements of slightly enriched uranium rods will be coated with a corrosion resistant metal.



PLANT	DEVELOPER	HEAT (KILOWATTS)	ELECTRICITY (KILOWATTS)	COST (MILLIONS OF DOLLARS)
PRESSURIZED WATER REACTOR	WESTINGHOUSE	264,000	60,000	85
EXPERIMENTAL BOILING-WATER REACTOR	ARGONNE	20,000	5,000	17
SODIUM REACTOR EXPERIMENT	NORTH AMERICAN	20,000	NONE	10
EXPERIMENTAL BREEDER REACTOR—II	ARGONNE	62,500	15,000	40
HOMOGENEOUS REACTOR EXPERIMENT—II	OAK RIDGE	3,000	NOT SPECIFIED	47
HOMOGENEOUS THORIUM REACTOR	OAK RIDGE	65,000	16,000	

Fig. 2. Experimental reactors to be built under the five-year development program are tabulated above. Only the pressurized water reactor will be a commercial scale power plant.

reactors built by the government or under the government's supervision to date; the many research reactors in use by private institutions are not included.

1. CP-1 (Chicago pile number one). In 1942, shortly after the establishment of the Manhattan Engineering Project and the discovery of the fission phenomenon by German scientists, Enrico Fermi constructed the world's first reactor primarily to prove the feasibility of a nuclear chain reaction and make way for the first atomic bomb. It was a uranium-graphite pile, constructed in a converted squash court under the West Stand of Stagg Field, the University of Chicago's football stadium, reaching a power level of no more than 200 watts of heat energy.

2. CP-2. This reactor was built at the University of Chicago after the dismantling of Fermi's first pile, in 1943. It utilizes natural uranium as fuel, graphite as moderator, and has lead and concrete shielding. Its 2000-watt power level requires no cooling system, as this rate of heat generation is not great enough to affect the reactor parts.

3. Oak Ridge Graphite Reactor. Using the same fuel and moderator as the two preceding reactors, this pile was constructed as a pilot plant for the Hanford Reactors soon to be built to produce fissionable plutonium. Circulating air is employed as a coolant, as the reactor produces heat at the rate of 2000 kilowatts. The cooling air is not heated to a high enough temperature, however, to make possible the production of usable power. This reactor is still in operation, the source of most of the radioisotopes shipped out to industrial firms and research institutes by the AEC.

4. The Hanford Research Reactor, similar to CP-2, was erected in 1944 to test materials intended for use in the plutonium-producing reactors.

5. The Hanford Production Reactors, discussed in a previous article in the ENGINEER, transformed U-238 into fissionable Pu-239 for the first atomic bombs.

6. CP-3, built in 1944 for research purposes, was the first reactor to employ heavy water as the moderator. Solid uranium bars, enriched in U-235 (15%) were suspended in tanks containing heavy water. CP-3 operated at a power-level of 300 KW, was cooled by circulating the heavy water through a heat exchanger.

7. The Water Boiler Reactor, completed in 1944, representing the first attempt at reactor simplification, incorporates both moderator and fuel in a uranyl nitrate solution containing 15% U-235. The solution boils in the course of the fission process, the heat being conducted away by circulating water flowing through the "pot" containing the uranyl nitrate.

8. "Clementine," completed in 1946, was the world's first "fast reactor," using pure fissionable Pu-239 as fuel; therefore, no moderator was required. Liquid mercury acts as the coolant, while the reactor operates at a power level of 25 kilowatts.

9. The Brookhaven Reactor, built in 1950, is identical in construction and operation to the Oak Ridge Graphite Reactor, but operates at a power level of 30,000 kilowatts.

10. The completion of the Experimental Breeder Reactor marked two milestones in atomic energy development; it was the first reactor to produce heat converted into usable electric power and, more important, it demonstrated what nuclear scientists had been postulating for several years: namely, that the "breeding" of nuclear fuels can be conducted at a greater rate than the original fuel is consumed.

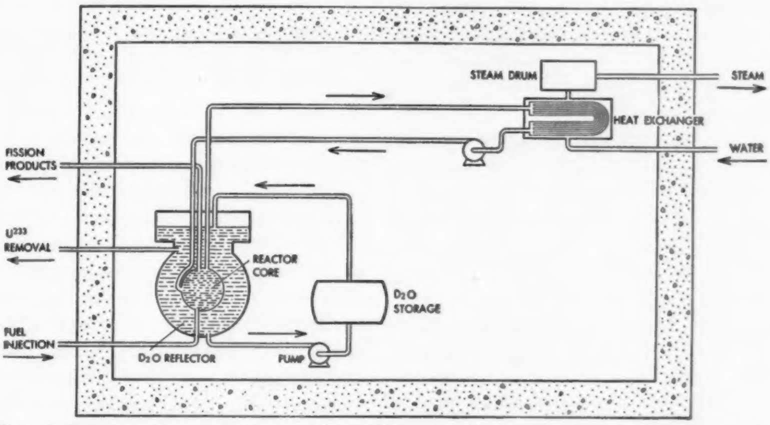


Fig. 3. Homogeneous reactor experiment-II, with the homogeneous thorium reactor modification of it also planned, is diagrammed here. Its fuel will be uranium dissolved in water, which undergoes fission and heats up. This heat, given up in the heat exchanger, generates steam for the turbine.

The reader will recall that the neutrons from the fission of a U-235, U-233, or Pu-239 atom can be utilized to transform a U-238 or Th-232 atom into a fissionable one. It is a closely guarded secret the number of neutrons freed when an atom fissions, but it is commonly known that it does exceed two. An inspection of Figure 1 will reveal that one of these is needed to sustain the chain reaction, and some will be absorbed by the shielding

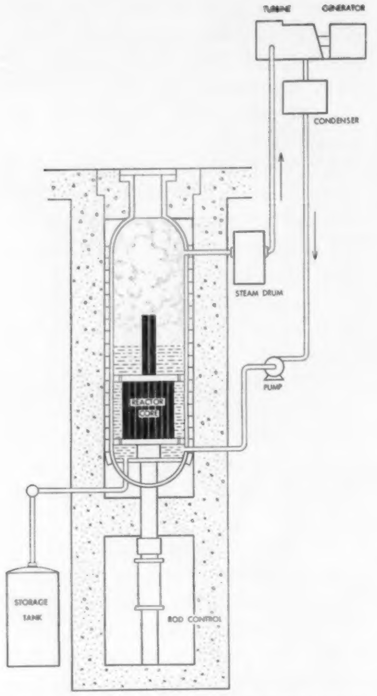


Fig. 4. Experimental boiling-water reactor has the advantage of a system in which water is heated to steam by the fission process in the reactor core and passes directly into the turbine.

or escape from the reactor. But the remaining neutron or neutrons must strike U-238 or Th-232 atoms and transmute them into fissionable atoms if breeding is to be successful. If only one new fissionable atom is produced per fission, we will be producing nuclear fuel at exactly the same rate as we consume it; but if more than one fissionable atom is produced per fission, we will be producing nuclear fuel at a greater rate than we consume it. It is just this latter possibility that the EBR substantiated; the importance of this discovery can be realized by noting the fact that, should breeding be impossible, only a very small amount of the mineable uranium and thorium in the world could be processed into nuclear fuel—until all the naturally-occurring fissionable atoms (of U-235) were consumed—and U-235 is quite rare indeed, comprising only 1/140 of a sample of uranium and enormously difficult to separate; however, the possibility of breeding insures that all naturally-occurring uranium and thorium can be utilized as nuclear fuels. It is then theoretically possible for nuclear power plants to breed fuels while simultaneously consuming fissionable atoms to provide heat. The possibilities of breeding where U-235 and U-233 are employed as basic nuclear fuels are much brighter than those where Pu-239 is utilized, because, at thermal speeds, the latter does not emit enough neutrons per fission to simultaneously sustain the chain reaction and breed new fuel.

EBR, fueled by pure U-235, has no moderator, and is cooled by liquid sodium or potassium, which enters the heat exchanger at 662° F. The steam produced operates a turbine which drives a generator of 250 KW capacity. The generator provides all electricity for the laboratory and enough power to operate the pumps propelling the coolant through the reactor.

11. The Materials Testing Reactor (MTR) was constructed in 1952 to observe the effects of nuclear radiations on materials proposed for reactor construction. Its fuel is moderately enriched uranium while water serves as both coolant and moderator.

12. Homogeneous Reactor Experiment (HRE). This reactor was erected to investigate the possibilities of incorporating fuel, moderator, and coolant in one substance, a liquid mixture such as uranyl sulfate. Electric power is produced as a by-product, although very uneconomically.

13. CP-5 was constructed in 1952 to replace CP-3, which was dismantled because it was situated on land the AEC was obligated to vacate. It employs enriched uranium fuel and heavy water as moderator and coolant.

14. Savannah River Production Reactors. These operate much as do the Hanford reactors to produce plutonium and tritium, an H-bomb fusible.

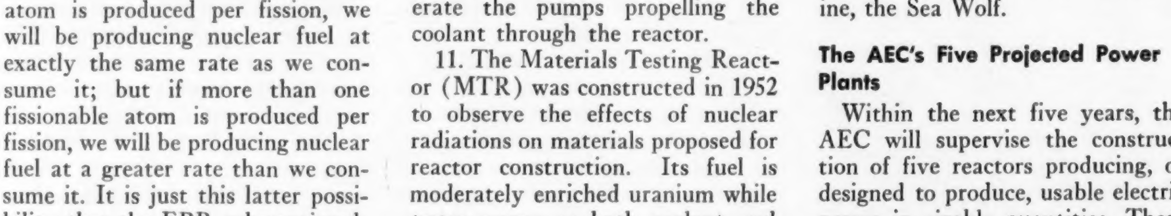
15. Submarine Thermal Reactor (STR). This is the reactor that propels the world's first atomic submarine, the Nautilus, developed by the Westinghouse Corporation. It operates in nearly the same manner as CP-3, except that ordinary water serves as the cooling medium and moderator. The circulating water is pumped to a boiler where steam is produced to drive a turbine which drives the submarine's screws.

16. A Sodium-Graphite Reactor is now in production to propel America's second atomic submarine, the Sea Wolf.

The AEC's Five Projected Power Plants

Within the next five years, the AEC will supervise the construction of five reactors producing, or designed to produce, usable electric power in sizable quantities. These five designs have been chosen ac-

Fig. 5. Sodium reactor experiment will consist of a comparatively old-fashioned core (like those in the Hanford piles) immersed in a cooling bath of liquid sodium. Slightly enriched uranium rods (solid black bars) run through channels in a graphite moderator (hatched bars). The liquid sodium surrounding the core circulates through a pair of cooling generators. To avoid the danger of placing highly radioactive sodium near water, the coolant is made to give its heat to a second sodium loop in the primary heat exchanger. The nonradioactive fluid then boils water in the secondary heat exchanger.



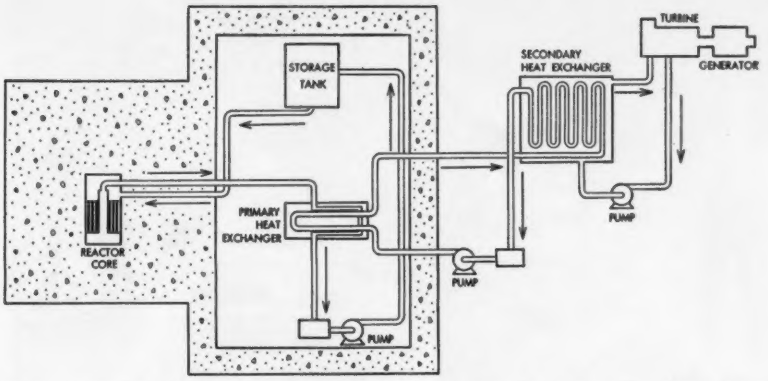


Fig. 6. Experimental breeder reactor-II is the fast breeder in the experimental program. Its design calls for a plutonium core, with no moderator, surrounded by a blanket of natural or depleted uranium (vertical black lines). Heat is removed from the compact core by circulating liquid sodium. As in the sodium reactor experiment, a secondary sodium loop serves to isolate the radioactive coolant from the boiler water.

cording to the experience thus far gained in reactor development and engineering considerations in the power field. The chart, Figure 2, lists these types, their costs, output, etc. They vary radically in use and composition of fuel, moderator, and coolant, but can be roughly grouped into those using liquid metal coolants, and those utilizing water, ordinary or heavy. In addition, homogeneity of operation is a basic distinction; that is, homogeneous reactors combine moderator, coolant, and fuel in one element.

Pressurized Water Reactor (PWR)

In October, 1953, the Atomic Energy Commission announced that a contract had been awarded the Westinghouse Corporation for the development and design of a pressurized light water reactor and accompanying central station type turbine and electric generating equipment, the plant to be operated by the Duquesne Light Company of Pittsburg. Construction was commenced on PWR April, 1954, near Shippingport, Pa. The plant, when completed late in 1957, will have cost $52,000,000, and will generate 60,000 KW of electric power. PWR will operate in much the same manner as does the power station of the Nautilus; atoms in uranium bars slightly enriched in U-235, immersed in highly purified ordinary water, will impart their heat, over 300,000 KW of it, to the surrounding water circulating at a pressure of 2000 psi and 525°F. through a heat exchanger (Figure 3). The latter will turn out steam at 600 psi, which will travel to a conventional turbine.

PWR is the least experimental of the power stations to be erected in the AEC's five-year program; it is to be built mainly to produce reliable, rather than cheap, power. Many reactor experts have labeled it the "least promising" of the five designs. Undoubtedly, later designs will render it completely obsolete. Nevertheless, it will stand out as the first producer of reliable nuclear power in this country.

Experimental Boiling Water Reactor (EBWR)

The Experimental Boiling Water Reactor (Figure 4) is to be built by The Allis-Chalmers Manufacturing Co. in conjunction with the Argonne National Laboratory of Chicago. Steam is to be generated in the reactor core and carried directly to the turbines; thus, costly steam generators and heat exchangers are to be eliminated. The system is to be water-cooled and moderated, using slightly enriched uranium fuel; pumping apparatus will be reduced by a factor of ten as compared with the PWR. More emphasis on leak-proof equipment must be considered in the design of EBWR, as radioactive steam will travel directly to the turbines instead of being diverted by heat exchangers. Also, the deposition of radioactive material on turbine parts may cause serious difficulties.

Homogeneous Reactor Experiment II (HRE-II)

A homogeneous reactor is one in which the fuel, coolant, and moderator are contained in one working substance. The HRE-II, modeled after HRE I, will consist of a uranyl sulfate solution which is pumped through heat exchangers to produce high-pressure, non-radioactive steam. HRE-II will be built at the Oak Ridge National Laboratory by Dr. Alvon Weinberg, its designer. The reactor consists, in Dr. Weinberg's words, of a "pot, a pipe, and a pump." Figure 3 shows the "pot," the inner portion of which contains the heated uranyl sulfate solution, the outer portion containing a heavy water reflector designed to minimize neutron loss. One great advantage of this reactor is the possibility that the core can be continously refueled while the system is in operation—fresh uranyl sulfate can be added without shutting down the reactor. Refueling a heterogeneous reactor demands that it cease operation so that uranium metal bars can be removed or replaced.

A variation of HRE-II, the Homogeneous Thorium Reactor, will be the first breeder to produce electric power in this country in sizable quantities. The D_2O reflector in the "pot" will be replaced by a thorium blanket which will be transformed into U-233 during operation of the reactor. This plant can theoretically be expected to operate indefinitely until the reactor parts wear out. One pays for operational simplicity in HRE-II and HTR with all the difficulties involved in handling billions of curies of radioactivity in solution under high pressure; all reactor parts and assemblies must possess absolute leaktightness.

Sodium Reactor Experiment (SRE)

North American Aviation, Inc., is undertaking to experiment with a reactor using sodium as a coolant which transfers heat from the fuel elements to the boilers (Figure 5). Construction has already begun in the Santa Susanna mountains near Los Angeles on this relatively conservative reactor design which will deliver over 20,000 KW of heat power, the conversion of which into electric power will not be attempted. Sodium as a coolant possesses a much greater thermal efficiency than water, and consequently will deliver power approximately two

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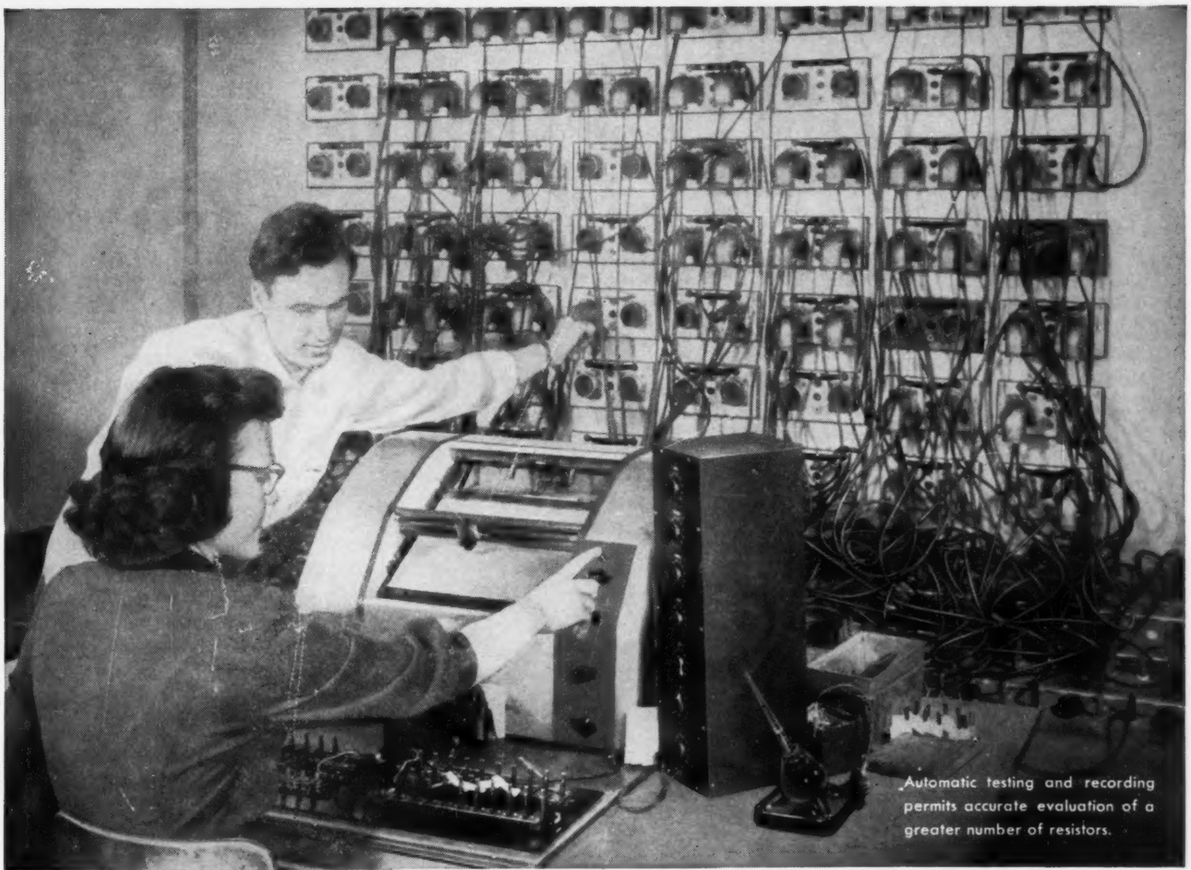

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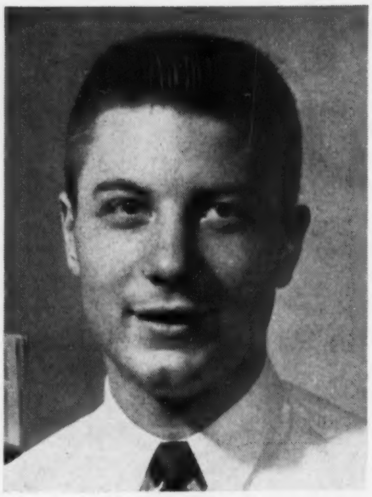
Brain Teasers

The ENGINEER is very happy to announce that the initial winner of the rejuvenated Brain Teasers column is Robert Warrington, a chemical engineer from the class of 1958. Bob was the first to mail in all the correct answers to the January puzzles.

Our February winner was Melvin Miller, ME '59, and the solutions for last month are as follows:

The first question concerned an N-piece jigsaw puzzle. Since every move will reduce the number of pieces by 1, N-1 moves will be required for a complete assembly, regardless of procedure.

The second problem involved a four by four checkerboard, in effect. Using such a concept, it is obvious that an odd number of steps will be required to reach the diagonally opposite (and therefore similarly colored) corner square. But the board contains an even number of squares (16). So entering each square exactly once while on the way to the diagonally opposite corner is an impossibility.



Bob Warrington

Our third question, a search for a word that will become shorter if you add a syllable to it, has a simple answer: "short."

Last of all, our card game was hopelessly crooked. Since the neutral cards were paired, the number of black pairs must equal the number of red pairs, and we will always have the same number of cards at the end of the game. So, you'll lose your entrance fee of a dollar every time you play, and the possibility of a financial gain is thus zero.

So much for the record. If you'd like to win three dollars just put the solutions to the following Brain Teasers in an envelope or on a postcard and mail them in.

No training required, just a little finesse.

1) A large cylindrical can has an inside diameter of 25 inches. What depth of water will be required to completely cover two steel balls in the can, one 14 and one 12 inches in diameter?

2) If I travel to Syracuse (a distance of 52 miles) at 30 m.p.h., at what speed must I return in order to average 60 m.p.h. for the entire journey?

3) What is the fallacy in the following operation:

$$1-3=4-6$$
$$1-3+9/4=4-6+9/4$$
$$(1-3/2)^2=(2-3/2)^2$$
$$1-3/2=2-3/2$$
$$1=2$$

4) And finally, to give the linguists a chance, we'll ask you to list a word containing a double vowel for each of the five vowels. Proper names and hyphenated expressions are not acceptable.

Answers next month.

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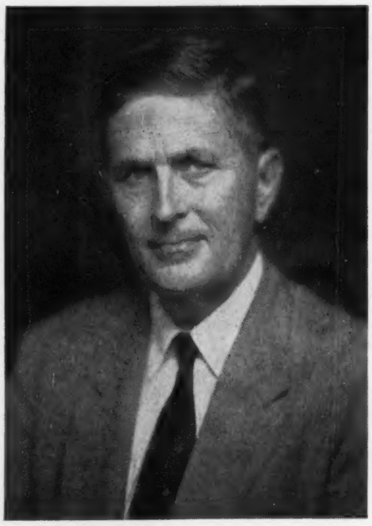

Walter M. Bacon

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates, and former students and to establish closer relationship between the college and the alumni."

TIME FOR ACTION

The following comparative statistics on the number of scientific and engineering graduates were recently published.

	1950	*1955*
United States	50,000	20,000
Russia	28,000	54,000

These are frightening figures. At a time when the demand for engineers is greater than ever before we are producing fewer each year. We cannot expect to maintain our lead in the world-wide technological race now taking place if this situation continues. How can we continue to improve our offensive and defensive weapons without the necessary manpower, not only to work directly on them but also to do the basic research and development on which they are bound to be based? All of us engaged in scientific and engineering careers as well as all Americans should give serious consideration to the gravity of this situation.

The engineering colleges of this country are today capable of handling many more students than are applying for admission. Even though engineering is a very satisfying career we cannot find enough interested and qualified students graduating from our secondary schools to fill our engineering colleges. High School students are not being encouraged to take up scientific and engineering careers and many schools are making no attempt to prepare their students for entering engineering colleges. In the past few years many other schools have dorpped the science and mathematics courses that are necessary for engineering college entrance. Another serious aspect of the problem is that an estimated 50 per cent of the students who do start taking scientific and engineering courses drop out before completing them. A large part of this loss is due to poor secondary school preparation which leaves the student unable upon reaching college to meet the demands placed upon him.

This makes a sad story but there is one thing that all of us might do as individuals to greatly improve the situation. We do have a great deal of influence if we wish to use it on the way our secondary schools are run. Many of us are members of school boards or are active in parent-teacher groups. Through these organizations we can, with proper pressure and perhaps a bit of selling, influence them to change. We also as individuals can talk to young people and interest those qualified to make engineering their career.

At Cornell we can accommodate many more engineering students and offer them an engineering education equal to or better than any to be obtained elsewhere. The extra year resulting from our five year curriculum is a great advantage and our graduates are better prepared and therefore more desirable to industry than the graduates of the four year colleges. Our University is anxious to do its part in providing the technical graduates that are so badly needed. We as individuals should also do our part and see that qualified young people take advantage of what the Cornell College of Engineering has to offer them.

W. M. BACON

ALUMNI ENGINEERS

Wallace R. Turnbull, M.E. '93, a pioneer in aviation research and development, died November 26, 1954 at the age of 84 in New Brunswick, Canada, near the spot where he first carried on his aeronautical research.

In 1902, after graduate study in Berlin and Heidelberg, Mr. Turnbull began his research in aviation. That was about a year before the Wright Brothers made their momentous flight. In the course of his research, he designed Canada's first wind tunnel and two hydroplanes. During the First World War he began investigating the practicality of variable pitch propellers and in 1927 patented the design for such propellers, now used on virtually all modern propeller-driven aircraft.

Perhaps the most noteworthy of his achievements were in the development of the theories of heavier-than-air flight at a time when such theories weren't readily accepted, together with an exact definition of such concepts as lift, drag, and center of pressure. These developments have had a tremendous influence on all subsequent aviation research.

Charles W. Hubbell, M.E. '07, retired last June after fifty years as a consulting engineer. His business experience has included: shipbuilding; manufacture of nonferrous metals; manufacture of locks, hoists, and trucks; plant construction and management; consultant for trade association; representative for the US Navy in aircraft plants from San Diego to Seattle; and technical writer and editor of instruction pamphlets. Hubbell's address is 419 Mulberry Street, Room 508, YMCA, Scranton 3, Pa.

Lewis B. Swift, M.E. '12, completed his fiftieth year with Taylor Instrument Co., December 4. In recognition of the event, The Taylor Meteor, trade journal of the Rochester firm, featured an article on Swift which detailed his rise in the company from clerk to chairman of the board. He lives at 37 Hancock St., Rochester.

Raymond Charles Burton, M.E. '21, associate supervising engineer of United Engineers and Constructors Inc., Philadelphia, has been elevated to the grade of Fellow of The American Society of Mechanical Engineers in recognition of his acknowledged engineering attainments.

Mr. Burton has been active in the design and construction of steam power stations, totaling more than one million kilowatt rated capacity. He was responsible for the design and construction of the $27-million Salem Harbor Station, the largest generating plant in New England, completed in 1951.

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Alumni Engineers

(Continued from page 35)

From 1922 to 1930 Mr. Burton was assistant engineer with the Public Service Corporation of Newark, New Jersey. Since 1931 he has been with United Engineers and Constructors Inc., Philadelphia. He has been responsible for a number of major power generating projects, including installations and extensions for the Richmond Station of the Philadelphia Electric Company; the Washington, D. C., Gas & Light Company; the Manchester Street Station of the Narragansett Electric Company, Providence, Rhode Island; the Montville Generating Station of The Connecticut Light and Power Company; and the Republic Steel Corporation, Alabama City, Alabama.

A. Haslup Forman, M.E. '31, has set up his own corporation, the A. H. Forman Co., Inc., 18 West Twenty-fifth Street, Baltimore 18, Md. The company specializes in acoustical treatment, sound control, ceiling suspension systems, resilient floor coverings, and sidewalk and industrial mastic. Forman lives at 7005 Copleigh Road in Baltimore.

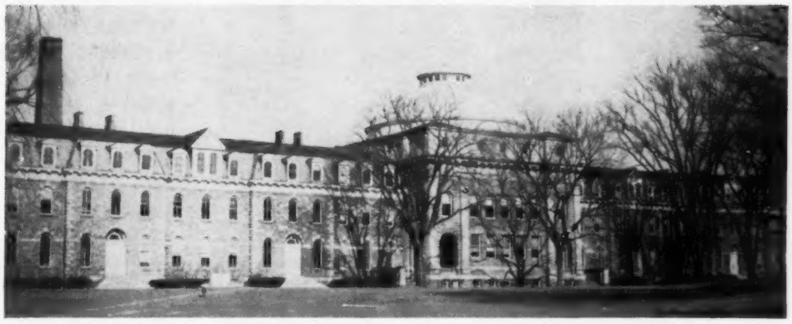
The assignment of **Robert M. Wilson, Jr., M.E. '32,** to act as a development engineer in the power field for the Development and Research Division of The International Nickel Company, Inc., has been announced by the Vice-President and Manager of the division.

For many years several engineers in Inco's Development and Research Division have directed considerable attention to the application of nickel alloys in power plants. The purpose of Mr. Wilson's assignment is to bring this activity to a focus in much the same fashion as other specialists in the division serve other major industries.

Mr. Wilson has been with International Nickel since February, 1946, when he joined the company as an engineer in the Technical Service Section of the Development and Research Division. Previously, he had been Welding Engineer at the Bloomfield, N. J., Works of the General Electric Company.

Mr. Wilson is a member of the American Welding Society and the American Society of Mechanical Engineers and has been active in Boiler Code work.

A Look at Engineering at Cornell



The Sibley College of Mechanical Engineering, administrative center for the College of Engineering.

To the prospective engineer:

For most high school students the choice of the "right" college is not an easy one. There are many fine universities and colleges in the nation, and in most cases sufficient information about all of them is not available to you. However, if you are thinking about Cornell, and you must be if you want a top-flight engineering school, we think you will be interested in the pages that follow. We have tried to sum up many aspects of engineering at Cornell that are not included in the usual brochures and catalogs. This is engineering at Cornell.

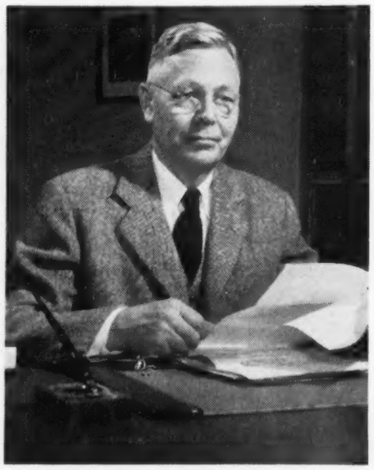
I. Why Choose Cornell?

Valuable vocational training recognized by employers combined with an opportunity to prepare for the whole of life mark Cornell's advantages for the incoming engineering student. The six major divisions of the College of Engineering attempt to provide essential technical knowledge to prepare workers for tomorrow's engineering age. In addition, they attempt to give the technically trained person a sense of appreciation of other areas of thought in order that he can lead a more effective, creative life.

A concrete testimony for the value of Cornell engineering education is given by the starting salaries offered by industry to Cornell graduates. Statistics based on actual placements in jobs of students graduating last June from all engineering schools reveal that the average starting monthly salary amounted to $400. This starting wage is the highest of any school in the country and is well over the national average of $370 for starting engineers. Last spring, Cornell engineers seeking permanent employment averaged almost ten interviews each by companies recruiting through the Office of Student Personnel.

Thus, industry is willing to pay a premium for Cornell graduates. Employers recognize the value of the five-year engineering curriculum by paying salaries that compare favorably with those offered men with Master's degrees.

Opportunities for scholarships available through the College of Engineering offer further incentive for selecting Cornell to obtain an engineering education. Last year 133 scholarships with an average stipend of $717 were awarded to freshman engineers. Over one-fourth of an engineering freshmen received assistance in the form of scholarships, the major part of



Deun S. C. Hollister

which come from the annual income of the $5,000,000 McMullen Scholarship Fund.

What are the advantages of a five (as opposed to four) year curriculum that characterizes all Cornell engineering courses? The extra year enables the student to work on a senior project of his own choosing, allowing independent research and development work to be carried on under the guidance of a faculty advisor. The project is a chance to utilize ingenuity and background knowledge in a situation involving actual engineering practice. The five-year course also provides an opportunity to achieve a more rounded education by pursuing some study in schools other than the engineering college. While admitting the impossibility of technical training within a liberal arts education, the five-year course still allows some balance to be attained between purely technical subjects and the humanities. The degree of that balance is dependent upon the individual student in selecting his elective courses. It is possible to elect about one fifth of the total courses required for an engineering degree in subjects not related to engineering.

A factor often overlooked in choosing a school for technical training is the possibility of change if the student should find he is not suited for an engineering career. The wide variety of other areas of study available at Cornell enable a student to transfer with a minimum of complications if he finds such a change is necessary. He need not break his social connections or other college ties if he desires to change courses. Rather, he can maintain his location and commitments while making necessary adjustments to a new program.

Cornell life itself is an important part of the overall growth that molds a useful citizen. Cornell University students form a varied cross section of American young people from all economic and social backgrounds. There are more than 500 foreign students at Cornell from about 70 different countries. There are students of all religious backgrounds because there is no discrimination in the admissions procedure. This cosmopolitan atmosphere provides daily opportunities to develop open mindedness, explore differing viewpoints, and practice tolerance and teamwork. Preparation of this nature is invaluable training to aid in peaceful future living.

Clubs and organizations for every interest combine with lectures, musical programs, athletic events,

and dramatic presentations to provide well-rounded extra-curricular activities for the Cornell student. Though engineering students must recognize the fact that their program of study will in many cases be more time-consuming and difficult than those of other schools, they can still participate in activities by intelligently budgeting their time. Social organizations provide a chance to develop a rounded personality. Active religious groups representing a variety of denominations, and the inter-faith program of Cornell United Religious Work enables the student to cultivate the essential spiritual dimension of his total being.

All students, particularly engineers whose programs present a more rigorous academic discipline, must recognize the fact that education cannot be measured by degrees, credit hours, or grades. Rather, it is measured by an awareness that there are vast areas of knowledge that cannot be explored by any one individual during his college career. The university atmosphere provided at Cornell acts as a stimulus for self-learning and self-investigation by the Cornellian that renders his education a life-long process. The academic spirit of Cornell University implies that specialization alone, exemplified by training at a technological institute, is not enough. In like manner, exposure to a collection of liberal courses in the limited environment of a small college is equally inadequate for life in the complex world college graduates must face. Rather, thorough technical training must be fused with a persistent interest to study and respect the totality of man's intellectual achievements. Cornell University and the Cornell College of Engineering offer the student an opportunity to develop this two-fold perspective in his college life.

This picture, taken looking down the Libe Slope at the Men's Dormitories, shows just one reason why Cornell is considered one of the most beautiful campuses in the nation.

Thus the classroom, shop, and laboratory facilities high above Cayuga's waters provide engineering training that is recognized by industry as outstanding. The cosmopolitan student life, varying social programs, and innumerable constructive student activities provide additional training to make Cornell engineers more creative citizens. Cornell University presents a daily opportunity to appreciate more fully the value of all knowledge, in a hope that its graduates will be continually challenged to relate their learning to the needs of their fellow men.

II. The Five-Year Curriculum

In 1925, Cornell lengthened its undergraduate architecture program to five years; in 1938, the chemical engineering program was lengthened to five years; and in 1945, the entire College of Engineering went over to the five-year concept.

These were radical departures from the venerable four-year process of education, and they were the result of lengthy and careful deliberation upon the part of faculty and administration. The major reason for these changes was that the growing complexity of the world was making greater demands upon the engineer, both upon his technical knowledge and upon his leadership. To prepare the engineering student for the responsibilities he must meet after graduation, a five-year program was needed. In such a program the student can receive a more thorough instruction in the basic sciences, indispensable in the study of later engineering subjects on the high level necessitated by the modern world. The five-year program also permits the engineering student to spend more time in the study of economics, government, philosophy, and the other fields of humanities, a knowledge of which is essential for leadership.

The five-year program prepares the graduate for both the present and the future. In the past twenty-five years science and technology have made earth-shaking advancements, figuratively and literally. The next twenty-five years will probably be more fruitful; the graduate of these next few years must be able to advance with science and be able to apply it, in all its complexity. To develop such an engineer, four years are not sufficient. In the five-year program at Cornell the broad technical education, the general education, and the inspired teaching form one of the world's best engineering educations.

It must be emphasized that Cornell's program is not the "three and two" program now found in several leading technical schools. Under the latter program, the student attends a liberal arts college for three years and then transfers to the technical school for his last two years. At the end of the five years, the student receives a B.A. from the arts college and a B.S. from the engineering school. Two highly reputable Eastern schools were studied in regard to this program. The three years in the arts college were under a fully prescribed program; the only choice the student had in his courses was in which foreign language he took. In his first year he was occupied with algebra and trigonometry; at the end of his three years at the arts college, he had taken only ninety credit hours of courses. His two years at the technical school gave him a total of six elective hours. After five years, the graduate had two degrees, but his engineering education, being the last two years of a four-year program was only of the quality of a four-year course. The Cornell student has had 103 credit hours by the end of his third year. In his five years, he has twenty-four credit hours of electives. Above all, he has had technical education on a higher level, because his courses have been carefully coordinated to best utilize his time. Furthermore, because of the careful coordination of courses and the presence of the university community, many values of liberal education can be largely realized in the professional phase of the program, a possibility lacking in the "three and two" system. The latter system also effectively destroys the greater rewards of extra-curricular activities. The student leader or athlete may ordinarily expect to reap his major reward during his senior year. Under the "three and two" system, what would be the student's senior year becomes a second freshman year at the technical school. The student must acclimate himself to an entirely new environment and system and thus it is extremely difficult for him to complete his extra-curricular development.

The five-year program at Cornell enables the student to develop to a greater extent than is probable in the compromise systems. Each engineering student receives a good general education, and he is able to choose in which fields he wishes to take most of his liberal courses. He is a member of a large university community, with the many opportunities it offers in cultural and social activities, and he receives a technical education which, measured by industry's starting salaries, is unsurpassed.

III. The Cooperative Plan

The Cooperative Plan is defined by a Cornell bulletin as "a course of study which schedules the student alternately between school and industry during a substantial portion of his undergraduate work." At Cornell, this plan was put into operation in 1947 for the schools of Mechanical and Electrical Engineering. It is primarily an educational method designed to develop the engineering student in certain ways impossible in the ordinary courses.

Under the cooperative plan, the year is divided into three periods, corresponding to the familiar periods of fall and spring school terms and summer vacation. The student follows a normal schedule for his first two years at Cornell. If the student then applies and is accepted into the cooperative plan, he will begin a program in which he will spend three periods in industry and nine in school (see Table 1). It should be noticed that whenever cooperative students are on campus in session, they are scheduled with their regular classmates. Cooperative students also graduate with their regular class.

TABLE 1

Calendar Periods	*Regular School Terms*	*Co-op Periods*
Summer	Vacation	5th term
Fall	5th term	in industry
Spring	6th term	6th term
Summer	Vacation	in industry
Fall	7th term	7th term
Spring	8th term	8th term
Summer	Vacation	in industry
Fall	9th term	9th term
Spring	10th term	10th term

There are certain advantages inherent in this plan:

First of all, the cooperative student "gets to see a side of the workman which is rarely revealed to the graduate of a regular course . . . Starting as he does as a rank beginner, the co-op . . . does not meet the wall of difference which confronts the man who . . . enters the shop as a 'College Graduate'."[1] He is more able to see "the workmen's point of view and their attitudes, their side of the labor question and their thinking on organized labor."[2] This knowledge will prove invaluable in later years in relations with fellow-workers and subordinates, as well as in earning promotions.

Secondly, the cooperative student

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(Continued from page 42)
through his knowledge of industry's requirements, is able to study more effectively than the student who does not know for what needs he is preparing.

Thirdly, the cooperative program shows the student the true nature of industry and the duties of various jobs in the industry. Thus "it certainly gives the man the opportunity to find out, at the earliest possible moment whether or not he is really fitted to do what he thinks he wants to do."[3] A student can determine whether he should change his field of study before such a change is rendered nearly impossible.

Lastly, the cooperative plan enables industry to provide a continual progression in jobs and a more beneficial type of supervision than can be provided during summer vacation work.

Admission into the program entails acceptance by the school and the cooperating company,[4] neither of which are mere matters of form. The student must possess a good scholastic record and good personal qualities. Upon graduation, the cooperative student is probably better fitted for industry than the regular-course graduate, and certainly the transition from school to industry will not be as large a step.

[1]From an article in the *Journal of Engineering Education*, March, 1953, by C. F. Arnold, Chief Engineer, Cadillac Motor Car Division, General Motors Corp.

[2]Ibid.

[3]Ibid.

[4]The cooperating companies, in the order of their joining the program, are Philco Corporation, General Electric Corporation, Air Reduction Company, The Proctor and Gamble Company, American Gas and Electric Service Corporation, and Cornell Aeronautical Laboratory.

IV. Extracurricular Activities

According to Webster's Dictionary, a student is "one who seeks knowledge from teachers or books; one devoted to learning." The same lexicon defines engineering as "the art and science by which the properties of matter and the sources of power in nature are made useful to man in structures, machines, and manufactured products."

From the literatus' viewpoint, the above material is sufficient for the definition of an engineering student. The prospective engineering student, however, may be apprehensive at this definition. Brought to mind are visions of days filled by complex and confusing lectures, and nights taken up with brain-wracking work—sleepless nights—impossible examinations—and the graduate is pictured as a fortunate survivor who has barely managed to last five century-long years of mental and physical hardship—a pale, nervous, emotionally wrecked but mentally stuffed being. Fortunately, this picture is far removed from the truth. The dictionary definition has no mention of football, track, or other sports—no hint of student councils, publications, dramatic clubs, and the myriad of student organizations open to the undergraduate in a large university. If the human temperament could be subjugated to a machine-like perserverance, a student could spend his five years solely on academic study without ill-effects. However, this self-control is very rare and perhaps dangerous to try unless one is conditioned. The wise student allots some of his time to activities outside of his academic field.

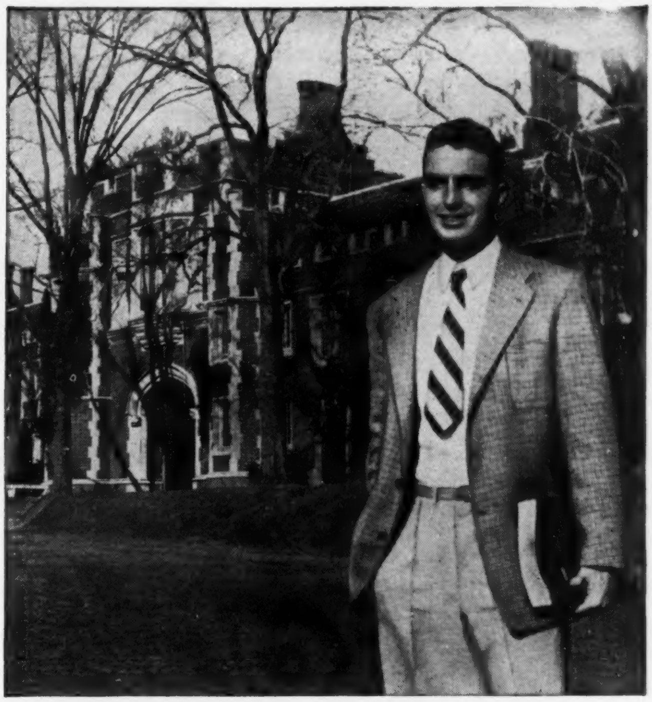
A Cornell player goes for yardage against Princeton in a game at Schoellkopf Stadium.

The majority of the engineering students at Cornell have found that a few hours a week spent in sports or student organizations provide many benefits: acquaintances, experiences, and broadened knowledge and viewpoint. Perhaps the most important benefit is the ability to tackle your school work with vigor and enthusiasm freshened or renewed by a few hours practice in a sport or working in an activity.

(Continued on page 46)

Donald C. Pote asks:

What bearing would my field of training have on my assignments at Du Pont?



DONALD C. POTE will receive his B.S. degree in Mechanical Engineering from Princeton University this June. He's been quite active in interclub athletics—football, basketball and baseball—and served a term as Club Athletic Director. He's also found time to work on "The Princeton Engineer" as Associate Editor. Right now, Don is making thorough plans for his employment after graduation.

CHARLES H. NOREN received his B.S. in Mining Engineering from the University of North Dakota before he entered the U. S. Air Force. Later he returned to school for an M.S. from the Missouri School of Mines, received in 1948. During the course of his Du Pont employment, Chuck Noren has had a wide variety of job assignments. At present he is engaged in a fundamental research project concerned with commercial explosives at Du Pont's Eastern Laboratory in Gibbstown, N. J.

"Chuck" Noren answers:

The answer to that is easy, Don, if you mean *initial* assignments. Generally speaking, a graduate's first assignment is influenced by his previous training and his expressed interest in a particular type of work. Whenever possible, Du Pont assigns a man to the type of work he is trained for and wants—he'll do better in any field if he's highly interested. For example, my master's thesis was on the use of explosives, and my first Du Pont assignment was a study of the efficiency of explosives.

But experience on the job really constitutes *new training.* You learn about other branches of science and engineering—you broaden your horizons through daily contacts with men having other skills. The result is that arbitrary divisions between technical branches gradually dissolve, and you become ready for new assignments and new responsibilities—even outside your original field. In my own case, I developed quite a bit of skill in mechanical and civil engineering techniques when I was called upon to supervise the "shooting" of an experimental tunnel for the evaluation of new explosives—even though my original training was in mining engineering.

Of course, specialization in a definite field may be continued if the man specifically wants it and reveals a talent for it. The best opportunities for that are in research and development. Naturally, the value of this kind of work is also recognized at Du Pont.

So, no matter what your initial assignment may be, Don, Du Pont is anxious to bring out your best. A good rule to remember is this. A graduate's *first* assignment is often necessarily based on his field of training and his degree, but his subsequent progress at Du Pont is *always* based on his demonstrated ability.

NOW AVAILABLE for student ASME chapters and other college groups, a 16-mm. sound-color movie—"Mechanical Engineering at Du Pont." For further information write to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Bldg., Wilmington 98, Delaware.

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

WATCH "CAVALCADE OF AMERICA" ON TELEVISION

(Continued from page 44)

A prospective engineering student may acknowledge the advisability of participating in activities but may feel that he himself will be unable to do so. He may feel that the courses will be too difficult for him to spend any time on other interests, or he may feel that as an engineer he will be unable to join the organizations of his choice and will be limited to engineering societies. The most lucid method of dispelling such beliefs is to show the large number of engineers in every organization. The majority of engineering students at Cornell participate in extra-curricular activities; each engineering school has its share of student leaders, its share of members in the dramatic Club, the Glee Club, or on a varsity team.

A short resumé of the major activities and the percentages of engineers in each will illustrate this point.

Men's Glee Club: 35% of the members, and all managers.

The Big Red Band: approximately 35%.

Red Key (junior service Honorary): 45%, including two officers.

Sphinx Head (senior honorary): 33%.

Scabbard and Blade (ROTC honorary): 38%, including two officers.

The 1st Vice-President of the Student Council; the Vice-President of the Interfraternity Council; both junior business managers of the Cornell Daily Sun, the student newspaper; the chairman of the Cornell Shows; and many other student leaders are engineers.

Of those who this year received numerals for freshman football, 27% were engineers; for freshman soccer, 38% were engineers; for freshman cross country, 64%. Of those who this year received the Cornell "C" for varsity football, 28% were engineers; for varsity soccer, 47%; "150 lb." football, 38%; for JV football, 18%; and for varsity cross country, 63%.

There are a large number of student organizations and sports open to the engineering student, and the freshman must realize that there are a great many facets to education, some of which must be found outside of the academic field. However, the freshman, as well as the upperclassman, should not allow his activities to obscure his academics, the core of an education.

V. Employment Opportunities After Graduation

To the prospective freshman, a detailed picture of the after-graduation job situation might seem to be of little value, since that picture is likely to change somewhat in the next five years. However, we hope the following overall picture will be of interest to anyone contemplating or engaged in a technical education.

Some Statistics

A former president of Rose Polytechnic Institute, Dr. D. B. Prentice, several years ago undertook a study in which he tabulated the collegiate backgrounds of all engineers listed in *Who's Who in Engineering*, 1931, 1937, and 1948 editions. Prentice found that the institutions most numerously represented were consistently, in this order, MIT, Cornell, Michigan, Illinois, and Purdue. He found, also, that in terms of percentage of total numbers of graduates from each institution, Cornell, among all the institutions of this country, was consistently in first place.

This points out a definite average superiority of Cornell engineering graduates, of which prospective employers are very much aware. The fact that this level of achievement is continuing up to more recent times is important, and we cite an analysis of the class of 1938 (this group having been in professional practice for 17 years), which yields the following summary:

Graduates in Engineering Design, Research, Development, and Consulting	36%
Graduates in Management (of technical enterprise)	43%
Graduates in Engineering Sales	12%
Graduates in Engineering Teaching	4%
Graduates in Non-Engineering	5%

Interpretation of the first group, design, research and development, and consulting, is difficult without being able to look fairly closely at the actual work being carried out by each member of the group, but it is significant that 42% of these have distinctive positions such as chief engineer, project chief, etc., indicating above-average leadership in technical thinking. The second group, over 40% of the class, consists of men in a field generally recognized as a measure of success, and while it is true that a management or administrative post does not always call for exceptional engineering talent technically, it is also true that most engineers who attain such posts do so through superior performance as engineers and through a demonstrated ability for leadership. Men in engineering sales, who must often exercise thorough understanding of the engineering work of their companies, also receive some of the higher rewards in terms of salaries. Many important positions are held, too, by graduates in the remaining two categories.

Salaries

Although an engineer must spend some time, often several months, becoming familiar with his com-

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pany and job, starting salaries as a rule are very high, a reflection of the present "shortage of engineers." Most industrial organizations have what they call "base rates" of pay, which depend only upon (1) the degree held by the new employee, and (2) the number of years of college the employee has had: a four or a five year curriculum, for example. Recognizing the value of a five-year curriculum in engineering, many companies now start a man holding a bachelor degree from a five year school with a salary equal to that paid a man with a masters degree from a four year school. This is a rather important consideraion when judging the usefulness of five rather than four years of education and the additional expense involved in a fifth year.

In addition to the base rate of pay, most companies make a practice of paying increments dependent upon summer job experience, army experience, participation in the summer "Co-op" plan, etc. These can raise the starting rate substantially.

It has been found that engineering graduates from Cornell University receive starting salaries averaging $400 per month, $15 to $30 higher than the average starting salaries of graduates from any other engineering schools in this country.

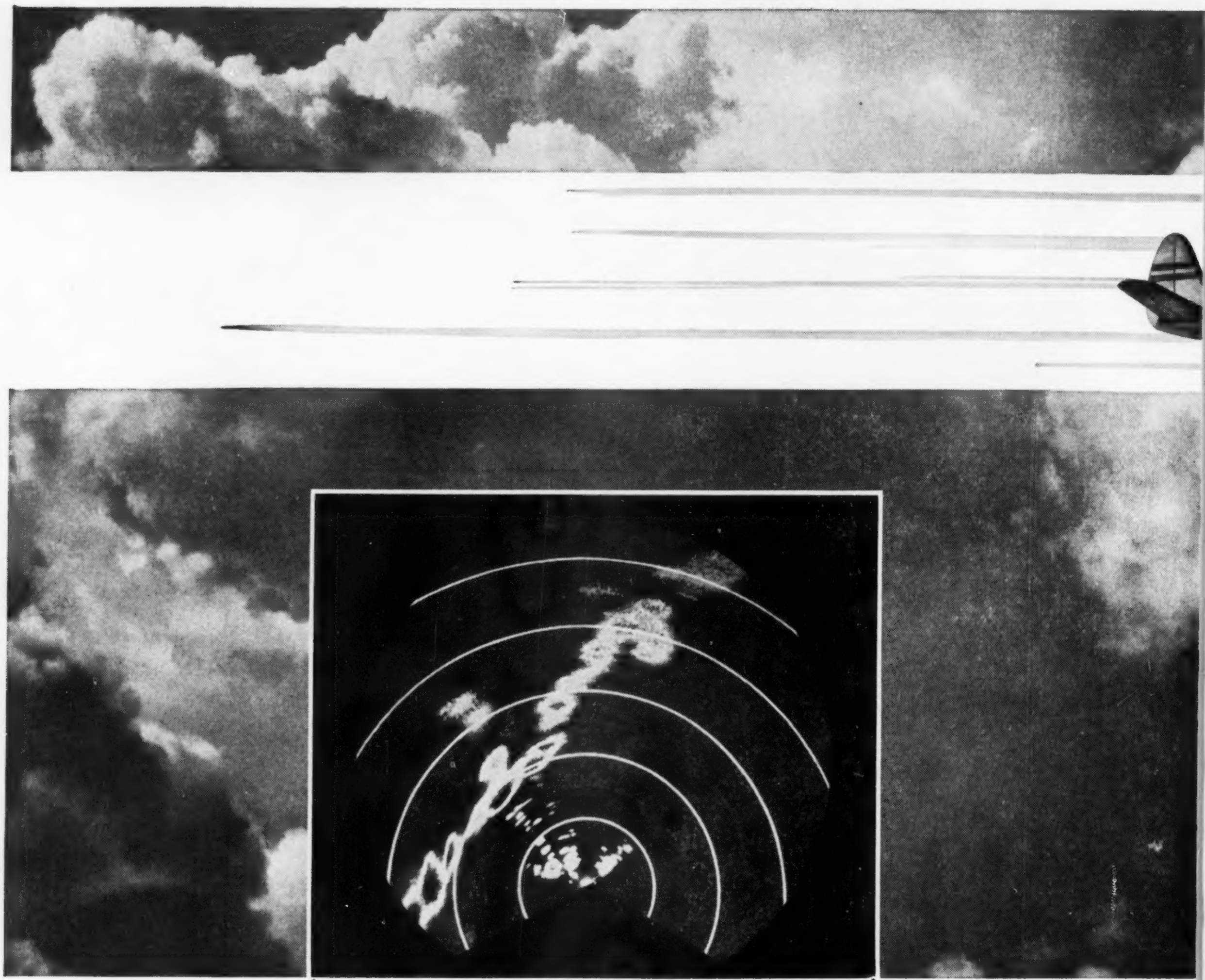
Placement services

Through the Student Personnel Office, the University provides facilities both for acquainting the student with his opportunities after graduation so that he may determine the type of job he wishes to enter, and for helping the student to "get the job." Every fifth-year student is assigned a placement advisor (there are two in mechanical engineering, one in each of the other schools) who keeps himself informed about available jobs for students in his field.

During the Spring Term of each year ("recruiting season" for the fifth-year students), representatives from about three-hundred industrial organizations visit the University to interview job-applicants, talk with interested students, and to review applications.

Also during the fifth year, so-called "non-resident lectures" are given students in the schools of mechanical and electrical engineering by men experienced in the problems of industry in an attempt to help the students anticipate situations likely to arise during their first few years after graduation.

While the entering freshman has plenty of time before he must become familiar with the exact mechanism of obtaining work after graduation, he may be more concerned (and justifiably so) with the prospects of summer work experience. It may be said that many companies make a practice of hiring properly qualified undergraduates for engineering work after their second year in school. Information on this subject may be conveniently obtained from the Student Personnel Office.



Actual storm ahead as pilot sees it on radar scope. It indicates that, by changing course very slightly, he will find a smooth, safe route.

Bendix AIRBORNE RADAR...

Bendix* Airborne Radar, a device carried right in the airplane to spot storms miles ahead, has been used by the military for several years. Now Bendix is supplying it to airline and company-owned aircraft.

This new device does what human eyes cannot do. It not only sees up to 150 miles ahead, even in the blackest night, but also looks right through storms and shows their size and intensity.

In the small photo above, for example, you can see white areas which are a line of storms. Those with black centers represent great turbulence. With only a slight change in course the pilot avoided these storms.

Airlines are buying Bendix Airborne Radar because it makes possible a more comfortable, swifter ride on a more direct course. Without airborne radar it has often been necessary to fly many extra miles to avoid storms whose areas and intensities were not definitely known.

Pilots hail it as one of aviation's most important developments, not only because of its storm-warning accuracy, but because it also acts as a navigational aid. Even in heavy overcasts it can see rivers, mountains and the outline of the terrain below. Write Bendix Radio Division in Baltimore for further information.

This is one of the hundreds of products Bendix has

Technibriefs

The concept of automatic electronic warfare was highlighted when General Electric opened its new 100,000-square-foot "Systems Center" for its Heavy Military Electronic Equipment Department.

The center will serve as headquarters for the company's development and manufacturing operations on powerful, extensive electronic "nerve centers" for military use.

Modern warfare is becoming so complex and fast-moving that electronic devices must do far more than simply present a military commander with bare information such as an image on a radar scope.

A typical electronic air defense system only begins its work by detecting an incoming bomber. The system first searches for and locates the plane. Then it tracks this target, predicts its position, computes all the factors necessary for fire control, and finally aims and fires the anti-aircraft weapons.

Such an electronic defense system employs radar, computers, target sighting and ranging devices, and the necessary communications equipment to link the entire operation together.

Timing and accuracy for such a coordinated defense operation are possible only through a well-integrated electronic system which does the entire job, eliminating duplication and unnecessary equipment and simplifying the operation.

Magnetic Pump

A new pump, designed to move liquid metals within cooling or heating systems, to force liquid metals into forms in die-casting operations, and for general usage wherever these metals must be forced from point to point, has been introduced by Callery Chemical Company of Callery, Pa. The unique pump also is believed to have applications in industrial atomic energy operations.

Operated on an electromagnetic principle, the new pump has no moving parts and no packing glands. Designed to pump liquid metals by means of an alternating current, the new conduction type pump can be operated from single phase, 60-cycle alternating current voltages.

The pump operates on a basic electromagnetic principle. The liquid metal to be pumped is, of course, a conductor of electricity. When an electrical current is passed through the metal, in a direction perpendicular to a magnetic field which surrounds the metal, it produces a force which sets that metal in motion within the pumping section. A pump of this type will effectively pump those fluid metals which have a lower electrical resistance than that of the pumping section's walls.

Mechanically, the pump is constructed with two current transformers, connected additively. These supply the current to an armature which is brazed to the tubular pumping section of the device at flattened portions of the tube. Current path through the armature is continuous across one flattened portion of the pumping tube, through the other side of the armature and across the tube's other flattened section.

The magnetic field is produced by four coils placed one on each of the legs of two U-shaped laminated magnetic field cores. These cores are attached to the device so that the ends of the U-shaped cores are against the flattened part of the pump tube, perpendicular to the direction of the armature. The coils on the cores are connected to supply the required flux in the proper direction.

Flow rates of the new conduction-type pumps are positively controlled from zero to maximum flow by an adjustable autotransformer.

Since this pump is symmetrical, the direction of flow of the liquid metal being pumped may be reversed by reversing the direction of the magnetic field with respect to the direction of the current through the pumping section. It is possible to do this even with the pump in operation.

Conduction type pumps may be used to move any liquid metal which will wet the pumping section and which has a high conductivity.

The pump can be installed in a hermetically sealed loop or in an open system. It can be welded or flanged into any system, according to specific needs. All pumps are equipped with welding connections; flanges or threads can be added as desired.

Printed Wiring Saves Time, Money

Indirect savings in the use of printed wiring for electronic equipment may be even greater than the direct labor savings, is the theory held by the G-E Light Military Electronic Equipment Department.

Printed wiring is circuitry formed directly on a circuit board. It replaces the maze of wires installed and soldered by hand in conventional electronic chassis.

Printed wiring used in a radar chassis not only resulted in lower manufacturing cost, but cut drafting manhours by one-third compared with a similar design using conventional wiring.

In another piece of equipment, use of a printed wiring design cut the number of drawings needed from 55 to 22, for a saving of almost 60 per cent. Square footage of drawings was cut almost 50 per cent, and the new design required but one special part compared with nine for a conventional wired chassis.

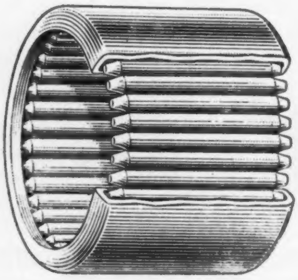
There is less emphasis and need for detail draftsmen in printed wiring designs but there is a greater demand for individuals who can translate vividly and rapidly a schematic or elementary diagram into a circuit.

Printed wiring is the foundation of the mechanized assembly of electronic equipment, and calls for increased coordination and integration between design and manufacturing engineering. The standardization of components for the printed wiring boards is one of the great challenges to the electronics industry.

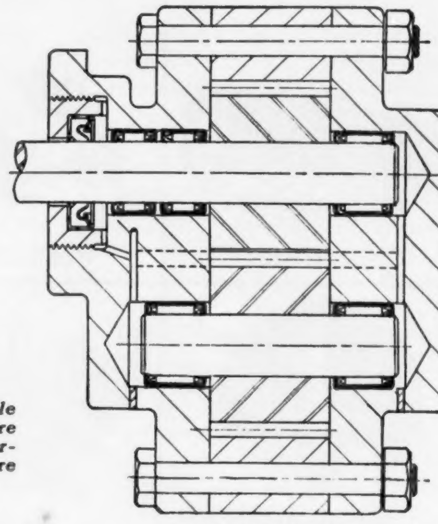
The Torrington Needle Bearing

proper housing design is essential to proper performance

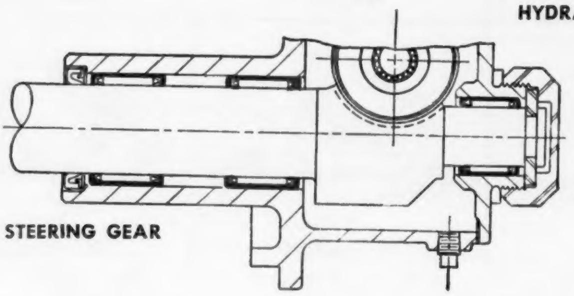
The Torrington Needle Bearing offers many design and operational advantages for a great variety of products and equipment. For example, a Needle Bearing has greater rated radial load capacity in relation to its outside diameter than any other type of anti-friction bearing. It is extremely light in weight. And it is easy to install and lubricate.



Needle Bearings require simple housings. If the housing bores are held to proper size, accurate operation and high radial capacity are assured.



HYDRAULIC PUMP



STEERING GEAR

Housing Maintains Bearing Roundness

The housing is an essential part of the Needle Bearing assembly. Care should be taken to provide a straight, round housing bore to the recommended tolerances.

The thin, surface-hardened outer shell of the Needle Bearing acts as the outer race surface as well as a retainer for the rolls. This shell assumes the shape of the housing into which it is pressed. Consequently, the housing bore should be round, and the housing so designed that it will carry the radial load imposed on the bearing without distortion.

Housing Material Determines Bore Size

The specified housing bore dimensions for any given material should be maintained in order to give the proper running clearance between the needle rollers and the shaft, and to assure sufficient press fit to locate the bearing firmly.

When designing housings of materials that are soft or of low tensile strength, allowance should be made for the plastic flow of the material when the bearing is pressed into place. Bore dimensions in such cases should be less than standard. Needle Bearings can be pressed directly into phenolic or rubber compounds, although metal inserts are recommended.

The new Needle Bearing catalog will be sent on request.

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

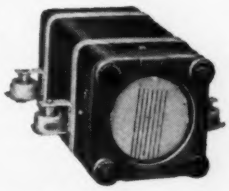
New RCA Radar "Weather Eye" Sees Through Storms

In our time, Man has won round after round in a contest against the elements that started thousands of years ago.

The most recent scientific victory is something new in Radar—an electronic "Weather Eye" developed by RCA.

In airplanes, this supersensitive instrument peers miles ahead. It gives advance warning of weather disturbances. The signals on its radar screen point the way to a safe course *around* storm areas, or even *through* them.

The leadership in electronic research that made the "Weather Eye" possible is inherent in all RCA products and services. And at the David Sarnoff Research Center of RCA, Princeton, N. J., scientists are continually at work to extend the frontiers of "Electronics for Living."



New RCA Weather Mapping Radar weighs under 125 pounds, takes little space in a plane.

For information regarding design and development engineering positions on such projects as "Weather Eye" Radar and military electronic equipment—write to Mr. Robert Haklisch, Manager College Relations, Radio Corporation of America, Camden 2, N. J.

RADIO CORPORATION OF AMERICA

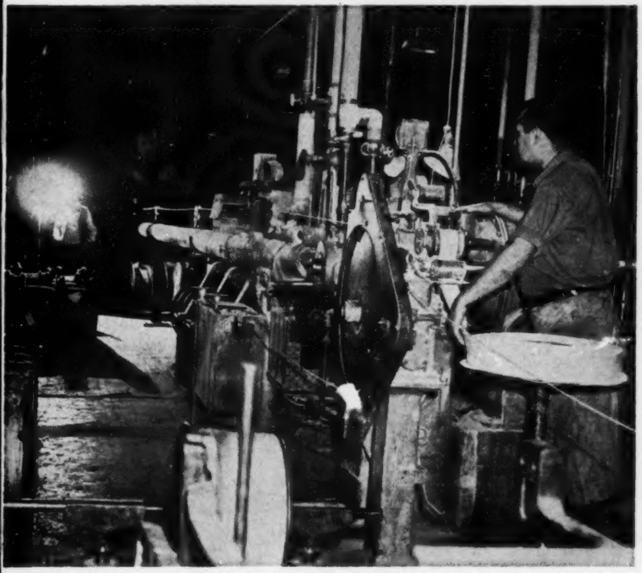
ELECTRONICS FOR LIVING

is adjustable with respect to the guide so that proper centering can be obtained. The guide and die are so located that there is an annular space between them through which the rubber compound reaches the conductor.

The driven screw of the extruder forces the unvulcanized compound through the guide and die assembly around the conductor. The equipment is provided with a driven take-up capstan which pulls the conductor through the machine and a revolving pan in which the rubber-covered conductor is laid. Successive layers of the covered conductor are separated with finely divided talc to prevent adhesion of successive layers during vulcanization. A tape may be applied over the insulation on larger conductors before vulcanization to assist in maintaining concentricity of the insulation with the conductor.

Rubber or rubber-like jackets are applied to rubber insulated single conductor cables or over the assembly of multiple conductor insulated cables by the extrusion process. Such jacketed cables are taken up in pans of talc as described for insulated conductors. A continuous lead sheath is applied over the unvulcanized jacket compound and the lead covered cable taken up on reels for vulcanization.

Continuous Cure Process



VULCANIZATION — The pans or reels containing the unvulcanized rubber insulated conductor or jacketed cable are then placed in a vulcanizing chamber where they are subjected to steam at the required pressure and for the required time to suitably vulcanize the rubber. The pressure is then slowly reduced to atmospheric pressure and the pans or reels removed from the vulcanizer and allowed to cool. The insulated conductors are then removed from the pans. This handling of the insulated conductor in pans through the extrusion and vulcanizing processes accounts for the term "pan cure process". Non-permanent tapes are then removed from strip insulated conductors and the lead tube from the jacketed cables.

CONTINUOUS CURE PROCESS—The continuous cure process employs a standard extrusion machine similar to that used in the pan cure process, but equipped with a modified head to which a vulcanizing tube is attached and provided with means for automatically controlling the temperature of the cylinder, screw and head.

The head differs from that used in the pan cure process in that the guide and die are mechanically centered with respect to each other and the compound space surrounding them is smaller. Centering of the guide and die is obtained by the use of accurately machined holders which fit snugly into perfectly centered openings in the head. This provides centering of the insulation or jacket compound at all times without adjustment by the operator. The compound space in the head is reduced to prevent premature vulcanizing of the highly accelerated compounds used in this process. Automatic control of the temperature of the cylinder, screw and head is required for successful extrusion of such compounds.

The vulcanizer attached to the tubing machine consists of a 2-inch steel pipe jacketed with a properly insulated 3-inch pipe and is approximately 125 feet in length. Vulcanizing steam pressure is maintained in the annular space between the vulcanizing tube and jacket to insure immediate attainment of the vulcanizing temperature when steam is admitted to the vulcanizer tube. The vulcanizer is provided with a splice box adjacent to the tubing machine and a suitable seal at the opposite end.

The driven screw of the extruder forces the unvulcanized compound through the guide and die assembly around the conductor or cable and directly into vulcanizer containing steam at 225 pound pressure. Highly accelerated compounds capable of vulcanizing in a few seconds are used so that the process can be operated at economical speeds. The speed of travel of a covered conductor or cable and the acceleration of the compound are so adjusted that the insulation or jacket is properly vulcanized while traveling the length of the vulcanizer. The vulcanized insulated conductor or jacketed cable is taken up on a suitable reel directly from the vulcanizer. The term "Continuous cure process" follows from the fact that the insulation or jacket is applied and vulcanized in one operation.

APPLICATION OF LATEX—The application of latex insulation consists of passing the coated conductor beneath the surface of a latex compound from which it is brought vertically into a suitable drying chamber. It continues to travel vertically in the chamber until the film is dry. It is then returned for the application of a second layer of compound. This alternate dipping and drying is continued until a wall of the required thickness is applied and dried. The amount of insulation deposited per application depends on the conductor size, the viscosity and temperature of the latex compound and the speed to which the conductor travels.

The conductor, covered with the required thickness of dried unvulcanized latex compound then passes through a vulcanizing chamber where the insulation is vulcanized and continues through a talc applicator to the take-up reel. This process is thus a continuous one in that the application of the insulation to the conductor and its vulcanization are accomplished in one operation.

Application of Latex

"NEW DEPARTURES" IN SCIENCE & INVENTION

LUCKILY, EUCLID WAS A GREEK

From the drawing boards at New Departure have come many of the world's ball bearing advancements. Such leadership is one reason why engineers everywhere specify New Departure ball bearings.

If Euclid had lived 2,300 years longer, he would have made Tau Bete. That's why he's pictured here wearing the Tau Beta Pi key.

After all, every engineer owes Euclid a big debt. At New Departure, for example, we work with circles and spheres. Without Euclid, we might still be getting started.

As it is, though, New Departure has gone further with spheres and circles in relation to moving parts than anyone else in the world. From this knowledge have come such advances as the Sealed-for-Life and the double-row angular-contact ball bearings. And it's advances like these that make New Departure the world leader in ball bearings.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL

College News

The Cornell Aeronautical Laboratory, Inc., has published a booklet that describes recommended minimum requirements for the automobile seat belts. The booklet, "Automobile Seat Belts—A Way of Living," is based on the results of several years of automobile crash research by the Laboratory.

Co-authored by Edward R. Dye, head of the Industrial Devision, and Alvin C. Smith, project engineer, the 16-page booklet describes in detail all phases of the seat belt with special emphasis on the strength requirements. Illustrations are by Laboratory Artist George Unger.

"The strength requirement of the seat belt is the focal point, since only a belt strong enough throughout will play its proper life-saving role," Dye and Smith wrote.

The two engineers stated that the belt should have a closed or buckled loop strength of 3,000 pounds, enough to withstand a crash up to 15 "G's." In a 15 "G" automobile crash, a 200-pound man would need a belt of that strength to remain in place. Fifteen "G's" represents a very severe crash, above which the auto's body structure would probably collapse.

The authors also write that although a number of satisfactory methods of attachment to the car exist, the load must ultimately be taken to the strongest anchorage possible—the frame of the vehicle. They state that a seat belt should never be fastened to the seat alone.

Some of the other sections of the booklet recommend that only one person should be restrained by each belt; that the belt should be adjusted snugly when worn to allow not more than four inches forward hip movement; that fitings, attachments, take-up devices and buckles resist slippage and failure under heavy tensile loads, and that belt parts in contact with the body be not less than two nor more than four inches wide.

Simplicity in operation of the buckle is another recommendation.

A special section of test methods describes four ways of determining whether a belt will meet the recommended minimum. Tests of fabric, assembly and anchorage are included.

Although the section is designed chiefly for engineers and manufacturers, the authors suggest the buyer would do well to demand evidence that the requirements set forth have been met.

Laboratory research was carried out in conjunction with the Cornell Committee for Transportation Safety Research, a group composed of representatives of the University at Ithaca, the Medical College in New York, and the Laboratory.

The booklet was prepared at Laboratory expense as a public service under an internal research project. It does not constitute an endorsement of any belt by any manufacturer, but merely outlines good and bad features of seat belts as determined by Laboratory research.

Interior photo of seat belt installation test. This is one of the final tests in evaluation of the effectiveness of seat belt installation as determined by the Cornell Aeronautical Laboratory.

Foreign Student Enrollment Up

With 503 students from 68 countries, Cornell has the largest foreign student enrollment in its history, Donald C. Kerr, counselor to foreign students, reports.

Of this number, 159 come from the Far East, including 45 from the Philippines, 34 from China and 29 from India. From South America come 105 student—26 from Colombia, 13 from Venezuela, and 11 and 10 from Cuba and Mexico.

Ninety-four students are from European countries, with the largest representations from England, Greece and Germany. Twenty-nine are from the Near and Middle East, 21 from Africa, and 95 from other areas, including 78 from Canada.

The opening of six new university dormitories gives greater opportunities for foreign students to live on campus this year.

In addition, 59 foreign students—30 percent of the foreign under-

(Continued on page 62)

College News

(Continued from page 60)

Wallace Rogers

graduate men — are members of fraternities, and five foreign women live in sororities. Another 17 students live in such private living units as graduate fraternities, Telluride House or cooperatives.

The College of Agriculture has the largest foreign student enrollment—173 students. The College of Engineering has 105, with 43 in civil engineering, 24 in mechanical engineering and 17 in electrical engineering. There are 101 foreign students in the College of Arts and Sciences.

Sixty percent of the foreign students are in the Graduate School, approximately 16 percent are women, and 239 students are enrolled this year for the first time.

New Manager of Purchases Named

Wallace B. Rogers has been named manager of purchases at Cornell University, succeeding John Jordan, Jr., who has resigned after 25 years with the university's purchasing department.

Mr. Rogers, a Cornell engineering graduate of the class of 1943, has been an assistant manager of purchases at the university since 1947, with responsibility for a variety of purchasing functions.

He was graduated from the purchasing institute conducted at Harvard Business School in 1950 by the National Association of Educational Buyers and is chairman of the NAEB's northern New York group.

He is secretary-treasurer of his Cornell class, financial adviser to Theta Chi fraternity and a member of the Cornell Society of Engineers and the university's committee on the alumni trustee election.

A native of Staten Island, he is 33 and a veteran of wartime Army ordnance service. He and Mrs. Rogers and their 1-year-old daughter reside at 615 E. State St.

NCA Appointments

Appointments to the twenty-eight technical committees and subcommittees of the National Committee for Aeronautics, for the year 1955, have been completed. The following appointments have been made from Cornell University:

Appointments—

Mr. A. Howard Hasbrook, Subcommittee on Flight Safety; Mr. R. S. Kelso, Subcommittee on Propellers for Aircraft.

Reappointments—

Mr. Allen F. Donoan, Subcommittee on Vibration and Flutter; Mr. William M. Duke, Subcommittee on Aircraft Structures; Mr. Alexander H. Flax, Subcommittee on High-Speed Aerodynamics; Mr. W. F. Milliken, Jr., Subcommittee on Stability and Control; Dr. William R. Sears, Subcommittee on Fluid Mechanics; Dr. Theodore P. Wright, Vice Chairman, Committee on Aerodynamics.

In the conduct of its business, which is scientific laboratory research in aeronautics, the Main Committee of the NACA is assisted in the determination and coordination of research programs by more than 400 specialists whose collective talents represent leadership in virtually every branch of the physical sciences.

These men, who receive no compensation, are selected because of their technical ability, experience, and leadership in a special field. They provide material assistance in the consideration of problems related to their technical fields, review research in progress both at NACA laboratories and in other organizations, recommend research projects to be undertaken, and assist in the coordination of research programs.

Atomic Energy

(Continued from page 29)

and a half times more efficiently from the heat obtained from the fissioning atoms. However, expensive and intricate sodium plumbing systems could nullify this reactor's apparent advantage over the more simply constructed water-cooled designs. A graphite moderator will serve to slow neutrons to thermal speeds.

Experimental Breeder Reactor Number 2

The first high-level power-delivering reactor to utilize the breeding phenomenon is to be built by the Argonne National Laboratory in Chicago. The Experimental Breeder Reactor Number 2 (Figure 6) will be a prototype of EBR-1; heat will emanate from a core of plutonium, the fissioning of which will breed more nuclear fuel from a surrounding breeder blanket of natural uranium. Since fast neutrons serve to obtain greatest breeding efficiency, no moderator is incorporated in the reactor design. Circulating liquid sodium will be the cooling medium. From time to time, the "breeded" plutomium will be removed from the reactor, processed, and either returned to the reactor or employed for other purposes. An inherent difficulty in EBR-2 and all fast breeders is the stringent precaution necessary to prevent radiation damage which fast neutrons are able to impose should they escape from the reactor.

"Packaged-Power Reactor"

The American Locomotive Company is now preparing to start construction of a baby reactor to be used by the army as a portable power plant, to be transported by air to such remote locations as beachheads where power is sorely needed. Intended to generate 2,000 KW, enough for a city of 2,500 people, it will cost in the neighborhood of $2,000,000, will require refueling but once a year. No doubt, an outgrowth of this project will be the design of small reactors suitable for export to remote areas of the world where power for peaceful purposes is non-existent today.

There exists a nearly uncountable multitude of engineering problems being encountered in reactor development and construction with which science has never previously been forced to cope, but these are beyond the scope of this article; however, a brief statement of some of these difficulties will give the reader at least a scanty insight into the work going on in the nuclear power field. For instance, an improvement on the efficiency of conversion of heat into electric power of water-cooled reactors is needed in order that these reactors compete with coal-burning plants in the generation of electricity, as water is inherently thermally inefficient. Since water is the sole coolant which can serve as a moderator, it definitely cannot be ruled out in reactor design. Still another problem is the reprocessing of nuclear fuel during reactor operation; homogeneous reactors probably offer the best possibilities in this respect, where continuous recycling of the liquid fuel makes possible the addition of new fuel in a relatively convenient manner, as compared to the shutting down of heterogeneous reactors to replace "burned-out" fuels. One other question dwells upon how long high-pressure radioactive water systems can be maintained leakproof to seal in death-dealing radiations. Serious corrosion problems will result in the use of radioactive steam and sodium and water coolants. Ultimately, all power-delivering reactors will be made breeders, most probably thorium breeders, in order to render the cost of nuclear fuel negligible; incorporation of breeding facilities in all power reactors is one design problem scientists will have to iron out once nuclear power begins competing with coal power.

Conclusion

The United States is not the forerunner in developing nuclear power for peacetime uses; the British have nearly completed a 50,000 KW installation in Northwest England which will start turning out electricity in less than a year, and plan to begin construction on a new one of greater capacity in the near future. Russia already has a small 5,000 KW nuclear power plant in operation, and is building new ones. Of course, the answer for the U.S.'s falling behind in the nuclear power field is evident: economic considerations do not en-

(Continued on page 66)

"I needed to 'Find' Myself— that's why I picked Allis-Chalmers,"

says A. J. MESTIER

Massachusetts Institute of Technology Sc. B.—1943
and now Manager, Syracuse District Office

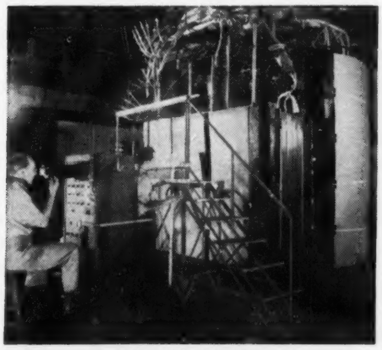
"I WAS LOOKING for an engineering job, but I wasn't very sure just what phase of this broad field would interest me most. I didn't know whether I wanted straight engineering, sales engineering, production or some other branch of industrial engineering.

"Allis-Chalmers Graduate Training Course gave me a means of working at various jobs—seeing what I liked best—and at the same time obtaining a tremendous amount of information about many industries in a very short time."

Experience Typical

"My experience is typical in many ways. I started the Graduate Training Course in 1946, after three years in the Army. My first request was to go to the *Texrope* V-belt drive department. From there I went to the Blower and Compressor department; then the Steam Turbine department. By the time the course was completed in 1948, my mind was made up and I knew I wanted sales work. I was then assigned to the New York District Office and in 1950 was made manager of the Syracuse District. The important thing to note is that all Allis-Chalmers GTC's follow this same program of picking the departments in which they want to work.

"Best of all, students have a wide choice, for A-C builds machines for every basic industry, such as: steam and hydraulic turbine generators, transformers, pumps, motors and other equipment for electric power; rotary kilns, crushers, grinders, coolers, screens and other machinery for mining, ore processing, cement and rock processing. Then there is flour milling machinery, electronic equipment and many others."

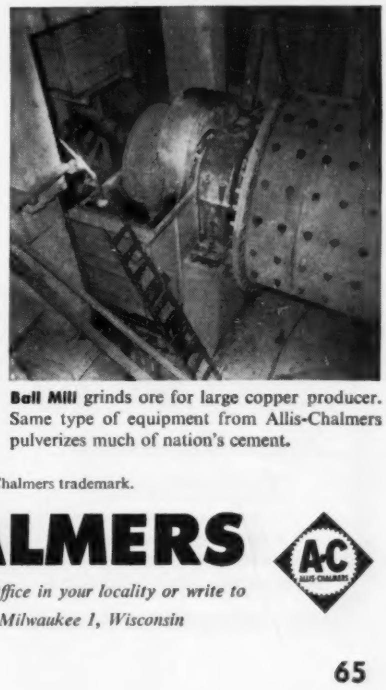


Taking surge voltage distribution tests on power transformer in A-C shops with miniature surge generator and cathode-ray oscilloscope.

A Growing Company

"In addition, new developments and the continuing growth of the company offer almost endless opportunities for young engineers.

"From my experience on the Graduate Training Course, I believe it is one of the best conducted in the industry and permits a young engineer to become familiar with a tremendous variety of equipment—both electrical and mechanical—which will serve him in good stead in his future profession."



Ball Mill grinds ore for large copper producer. Same type of equipment from Allis-Chalmers pulverizes much of nation's cement.

Texrope is an Allis-Chalmers trademark.

ALLIS-CHALMERS

For information call the Allis-Chalmers District Office in your locality or write to Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

Atomic Energy

(Continued from page 64)

ter into Russian plans for developing nuclear power, while the capitalist economy in America will not absorb any new process unless it is feasible price-wise. In Britain, coal power costs twice as much to produce than over here, so that nuclear power already has its work cut out. However, it will be but a very short time before American homes will be receiving kilowatt-hours of electricity from the same source that propels our newest submarines and will soon provide our warplanes with unlimited range.

Filters

(Continued from page 8)

restaurants, and offices use them both to cut down maintenance costs and to improve the healthfulness of the air. Textile plants and breweries find the electronic filter helps keep their products uniform and of high quality. Hospitals, food processing plants, pharmaceuticals, and laboratories use them to maintain a clean and sterile atmosphere. Electronic filters have also been found particularly effective in removing radioactive particles from the air. As evidence of this, the Atomic Energy Commission is using them in many of its operations, and research is now being carried on to investigate the possibilities of their use in lessening the dangers of radioactive dust created by an atomic explosion.

A more specific use of electric filters, which illustrates how adaptable such filters are, has been developed in connection with precision machine tools such as high speed lathes and grinders. The filter is used to recover the oil mist formed by the coolant used in such machining operations. Special intake hoods and oil return systems have been developed so that the oil mist will be drawn through the electrostatic precipitator where it collects on the aluminum plates, flows off into collecting pans, and finally is run back to the machine for re-use. Aside from saving money in recovering the coolant, the precipitator makes certain that the machine operator is no longer liable to inhale any oil mist, and also decreases maintenance costs and safety hazards by eliminating the film of oil which collects on floors and machines.

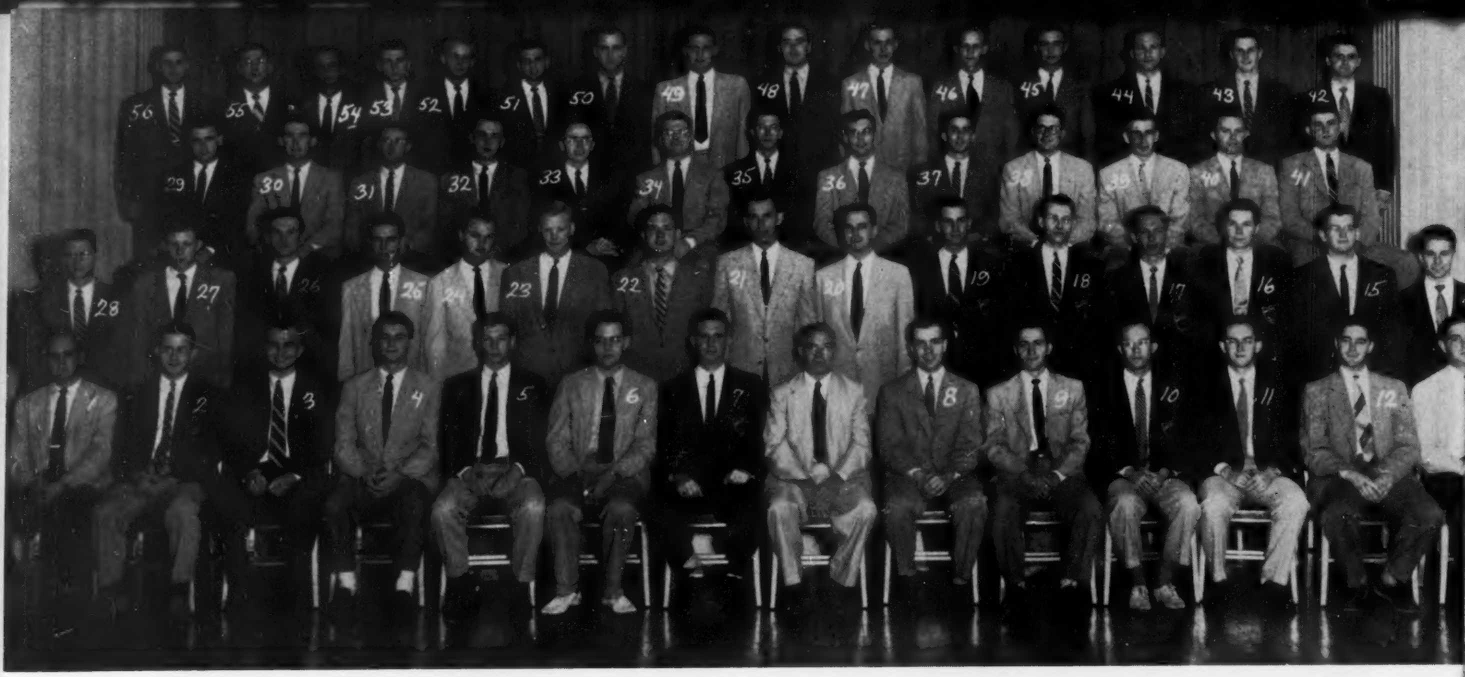
Although many of its uses involve specialized adaptations such as the one discussed above, there are certain general features about the electrostatic filter which can not be ignored. Such a unit can be easily installed in any air conditioning system and operated at nominal cost. Furthermore, it will remove virtually all pollens, dust, bacteria, and virus from the air to provide an atmosphere which could hardly be more conducive to good health and high quality, uniform production of goods. Many more applications will surely be found for electrostatic filters, too, as people demand better products from industry and healthier places in which to live and work.

Aviation in Ithaca

(Continued from page 20)

1929 a public announcement was made that the Thomas-Morse Aircraft Corporation had been sold to Consolidated Aircraft in Buffalo. Consolidated was later to become the Convair Division of General Dynamics Corporation, a leading modern aircraft manufacturer. The days of castor oil, pilot training, leaky seaplanes, and flights from the ice were ended. The famed Tommy scouts, the MB-3 pursuits, and all-metal pioneers would no longer cautiously take to the air from the field near Lake Cayuga. The disappointments of designs that didn't make the grade, and the success of record breakers were over. The aircraft factory was converted to adding machine production.

But the story continues. Convair has come into its own with its popular "340" passenger airliner, its F-102 jet fighter, and its R3Y-1 turbo-prop seaplane. Such planes are the latest part of a challenging tradition of courage, ingenuity, and mistakes that have been persistently corrected. Thomas-Morse in Ithaca, N.Y. is a significant part of that tradition—contributing to an advancing air progress that is today only beginning.



School of Mechanical Engineering

Class of 1955

1. Miller, R. H.
2. Trego, J. W.
3. Faber, E. C. Jr.
4. Franklin, D. C. Jr.
5. Rose, V. H.
6. Glover, R. C.
7. Glickman, D.
8. Mountsier, W. W.
9. Beningoso, H. D.
10. Cherkasky, M.
11. Delaplane, R. E. Jr.
12. Dalsheimer, G. H.
13. Vail, J. D. Jr.
14. Richards, D. E.
15. Liebskind, A. S.
16. Swecker, R. S.
17. Brunner, J. W.
18. Buettner, J. H.
19. Sterling, R. Jr.
20. Colby, M. D.
21. MacPhee, W. T.
22. Giruc, T. P.
23. Kennedy, R. D.
24. Nicholls, M. B. Jr.
25. Whitney, H. H.
26. Blatz, A. A.
27. Knuth, D. F.
28. Carhart, D. R.
29. Lennon, J. J.
30. Casey, F. M.
31. Schusler, R. M.
32. Schlerf, G. W.
33. Leng, J.
34. Knoblock, R. E.
35. Skeen, J. H.
36. Strong, S. S.
37. Deskey, D. S.
38. Cowing, W. C.
39. Gruetter, R. D.
40. Reidenbach, F. N.
41. Simon, W. P.
42. Weston, K. C.
43. Breckenridge, R. W. Jr.
44. Fauntleroy, C. G.
45. Eschenroeder, A. Q.
46. Morrison, R. M.
47. Allison, R. R.
48. Hewitt, E. W.
49. Anderson, M. H.
50. Partridge, A. L. Jr.
51. Kolton, B. D.
52. Boss, W. L. Jr.
53. Reichenbach, A. F.
54. Musso, A.
55. Donovan, W. P.
56. Champlin, D. L.
57. Kahle, R. V.
58. Schneider, R. T.
59. Martin, J. H.
60. Hardy, H. B.
61. Grevatt, M. K.
62. Arnott, T. H.
63. Conill, E. J.
64. Go, B. T.
65. Friedman, M. G.
66. Bael, R. L.
67. Boghossian, V. O.
68. Delaney, G. F.
69. Heinzelman, F. E. Jr.
70. Noyes, R. C.
71. Quick, L. S.
72. Gauthey, J. R.
73. Eyman, D. S.
74. Posner, R. A.
75. McClellan, T. O.
76. Power, D. W.
77. Blesch, J. A.
78. Cook, O. E.
79. Cooper, C. T.
80. Booth, I. M.
81. Abbott, J. W.
82. Schneider, D. A.
83. Richardson, W. S.
84. Berg, D. L.
85. Geis, N. P.
86. Krech, E. M., Jr.
87. Peters, W. L.
88. Weaver, J. S., Jr.
89. Jensen, F. O.
90. Saderholm, C. A.
91. Oliva, J. J.
92. Minners, W.
93. Morrisey, D. C.
94. Soave, R.

ALLISON Engineers Break Ground for New Turbine Engine Test Facilities

E. B. NEWILL, Georgia Tech, '15, now General Manager, Allison Division and Vice President of General Motors Corporation, breaks ground on another addition to our turbine engine test facilities.*

Allison Jet engine designers soon will have even larger and improved test facilities to use in developing turbo-jet engines.

Performance requirements for future military and commercial aircraft make necessary the development of new turbo-jet engines far more complex and powerful than present types. New and specially-designed test equipment is required to accurately determine performance of the principal engine components—compressors, turbines, and combustors—before the complete engine is tested.

For instance, capacity for 75,000 horsepower is being established to pump air at the rate of 300 pounds per second. This air must be compressed and heated to 1000 degrees, or cooled to a minus 67 degrees, enabling Allison to test combustors at simulated altitudes up to 65,000 feet.

With our expanding and long-range engineering program, we need additional young engineers. Allison, a leader in the design, development and production of turbo-jet and turbo-prop engines, NOW offers young graduate engineers unusual opportunities for progress where future development is unlimited.

Write for information:

R. G. GREENWOOD, Engineering College Contact
ALLISON DIVISION, General Motors Corporation
Indianapolis 6, Indiana

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* Left to right—Dimitrius Gerdan, Chief Engineer, Turbo-Jets, U. of Michigan, 1932, BS in Mechanical Engineering and Industrial Engineering; T. W. Meeder, Chief Test Engineer, U. of Michigan, 1932, MS in Aeronautical Engineering; R. E. Settle, Assistant Director of Engineering, Purdue University and Indiana Central College, BS in Mathematics; Paul Hunt, representing Huber, Hunt & Nichols, Inc., contractor; E. B. Newill, Georgia Institute of Technology, degrees in Mechanical and Electrical Engineering; Harold H. Dice, U. of Illinois, 1929, BS Business Administration; Col. S. A. Dallas, USAF Plant Representative; R. M. Hazen, U. of North Dakota, U. of Michigan, 1922, BS in Mechanical Engineering and attended graduate school, U. of Minnesota, majoring in Metallurgy.

STRESS *and* STRAIN...

Out of the wild and wooly West comes this hazardous adventure. It seems that a grizzled oil prospector was reminiscing for a bunch of New England tenderfoots. "There I was," he drawled, "trapped in a narrow draw with a hungry ole grizzly not twenty yards away behind a tree. Th' only way I could figger to bag the crittur was to ricochet a ball off th' canyon wall to th' right. Now being' a champeen shot like I am I just gauged th' wind, judged th' lead of th' barrel and th' rate of twist, th' hardness of th rifle ball and th' angle of yaw it'd have bein' smacked outta shape agin th' wall, and I figered my chances of nailin' thet bar were about 70-30. A one rail bank shot. A controlled ricochet. So I let fly."

The old man paused. Softly one of the tenderfeet gasped, "Did you get him?"

"Nope," replied the prospector. "Missed the wall."

* * *

Two commuting students were sitting together as they rode home on a crowded subway car, when Charlie noticed that Vernon had his eyes closed.

"What's the matter, Vern," he asked, "feeling ill?"

"I'm all right," replied Vernon, "but I hate to see women standing."

* * *

A young flapper breezed into a florist shop and looked around the shelves for something she wanted. Spying an old fellow puttering around a plant in the corner, she walked over to him.

"Have you got any passion poppy?"

"Gol ding it!" he exclaimed. "You just wait 'til I get through pruning this lily."

* * *

"Let's make a date for Saturday."
"I have a date for Saturday."
"Then let's make it Sunday."
"I'm going out of town Sunday."
"How about Monday?"
"Oh, heck, I'll go Saturday."

The bandage-covered M.E. who lay in the hospital spoke dazedly to his visiting pal.

"Wh-what happened?"

"You absorbed too much last night, and then made a bet that you could fly out the window and around the block."

"Why didn't you stop me?" screamed the beat up student.

"Stop you," said the other? "I had ten bucks on you!"

* * *

The telephone rang late one night.

"What is it?" asked the tired C. E.

"It's a long distance from New York," replied the operator.

"I know it is," said the C. E. and back he went to bed.

* * *

A group of prohibitionists looking for evidence of the advantage of total abstinence were told of an old man 102 years old who had never touched a drop of liquor. So they rushed to his home to get a statement. After propping him up in bed and guiding his feeble hand along the dotted line, they heard a violent disturbance coming from another room—furniture being smashed, dishes being broken and the shuffling of feet.

"Good heavens, what's that?" gasped a committeeman.

"Oh," whispered the old man as he sank exhaustedly into his pillows, "that's Pa, he's drunk again.

* * *

Two drunks wandered onto a railroad trestle one dark night.

First drunk: "Boy! Thish is a long flight of stairs."

Second drunk: "I don't mind that so much, but I'm having a heck-of-a-time getting used to thish low hand rail."

* * *

Prof.: "Why don't you answer when I call your name?"

Student: "I nodded my head."

Prof.: "You don't expect me to hear the rattle all the way up here do you?"

Have you heard the new radio program about the girl who wanted two bathrooms? It's called "The Wife's Other John."

* * *

An inmate of a certain insane asylum, feeling that he had recovered enough to be released, was partially examined and asked the following question:

"If we discharge you, will you promise to let women and liquor alone?"

"Yes sir."

"Lock him up; he's still crazy."

* * *

During mock maneuvers an army commander ordered a notice to be displayed on a bridge stating: "This bridge has been destroyed by air attack." But to his chagrin, he noticed through his field glasses that a foot regiment was crossing the bridge despite his orders. He sent his adjutant to the officer in charge poste-haste to find out how he dared to defy his orders. An hour lated the adjutant wcs back. "It's all right, sir," he reported. "The troops are wearing signs saying, 'we are swimming'."

* * *

Stern parent (to applicant for daughter's hand): "Young man, can you support a family?"

Young man: "I only wanted Sarah."

* * *

"Could you," the specialist asked, "pay for an operation if I found one necessary?"

"Would you," countered the patient, "find one necessary if I couldn't pay for it?"

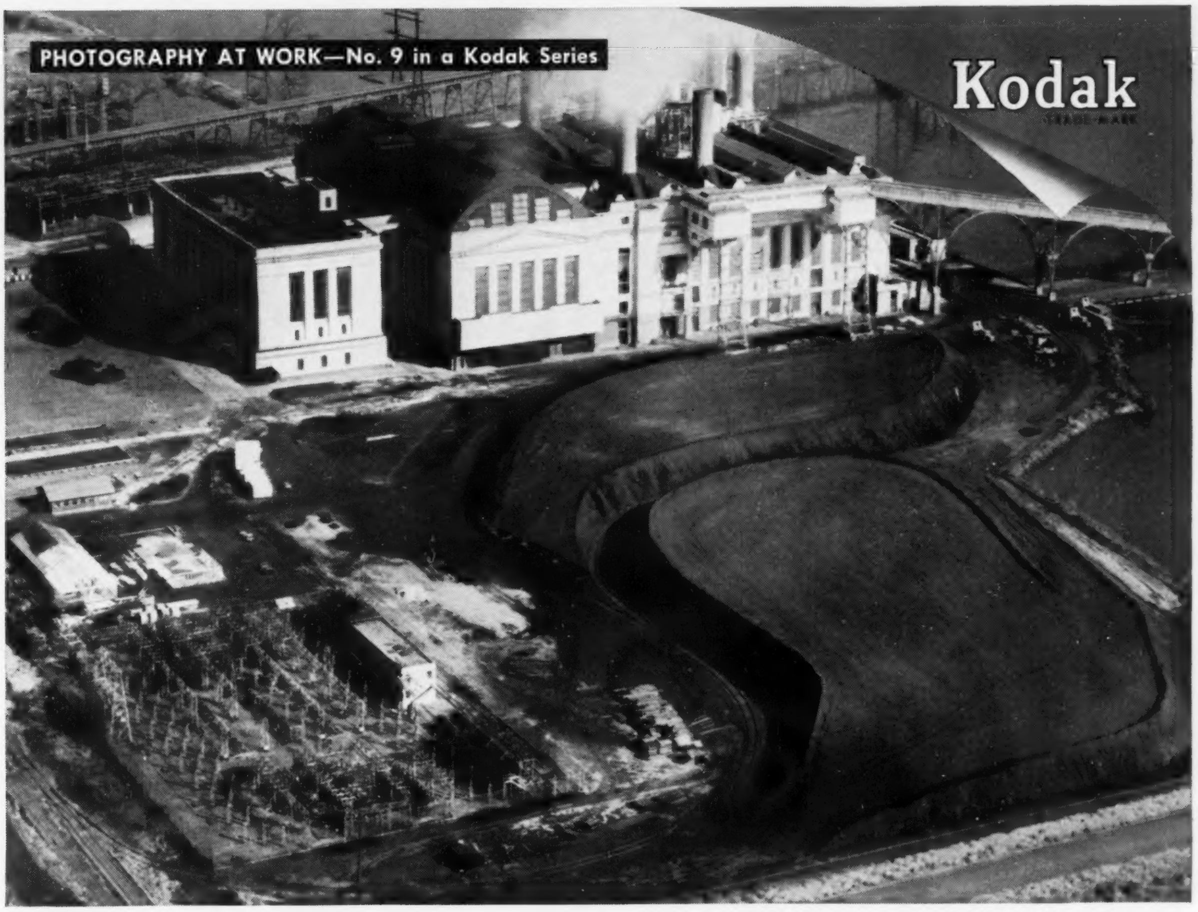
* * *

"Hey! Did you see that young lady smile at me?"
"That's nothing. The first time I saw you I laughed right out loud."

* * *

Tourist Guide: "We are passing the largest brewery in the United States."

M.E.: "Why?"



Richmond Station of the Philadelphia Electric Co.

Weeks of work shrink to days as

photography weighs mountains of coal

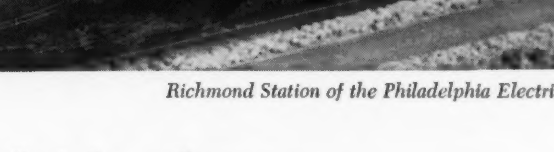
Aero Service Corporation takes stereo pictures of the coal piles at a utility's 10 storage sites—reports the fuel reserves on a single inventory date at 25% lower cost than with other methods

It used to take a surveying crew weeks to measure and figure the contents of the Philadelphia Electric Co.'s big coal piles. Now a camera and an airplane work together to cut the time to days. Overlapping pictures are taken from the air. Then with stereo plotting equipment the volume of the heap is calculated.

Streamlining the inventory job is a natural for photography. It's being used to count metal rods, automotive parts, telephone calls as well as tons of coal. But photography works for business in many other ways as well—saving time, reducing error, cutting costs, improving production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning service man, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Aero Service Corporation takes its stereo photographs and translates them into a contour map of 1-foot intervals. Each 1-foot stratum of the coal pile can then be measured with a planimeter and its volume computed.



Eastman Kodak Company, Rochester 4, N. Y.


WHERE PROGRESS IS UP TO YOU...
What will you add to jet engine progress?
New, dramatic advances being made at General Electric's aircraft gas turbine operations bring into clear focus the vital role recent college engineering graduates play throughout the company. Typifying such responsibility are R. W. Bradshaw, ME, Lehigh, '48, responsible for design of development engine controls and accessories, and B. C. Hope, EE, UCLA, '49, supervisor of test programs for development of aerodynamic and mechanical components.
In every field from electrical, mechanical, metallurgical and aeronautical engineering to physics and chemistry, young men like these broaden their technical background in GE's after-college program of practical engineering assignments. In this program, as in his ultimate career, the engineer chooses the field and location—from the entire range of G-E activities including plastics, large electrical apparatus, electronics, jet propulsion, automation components and atomic power.
Working with world-renowned G-E engineers, you—like Bradshaw and Hope—can make important contributions early in your engineering career. For full details on the G-E career suited to your talents and interests, see your college placement director, or write General Electric Company, Engineering Personnel Section, Schenectady 5, New York.
TR-1A
Progress Is Our Most Important Product
GENERAL ELECTRIC